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The importance of dependable electric power equipment is evident. Banks of transformers, as shown here, must feed the energy for the many, many operations—and back of them is the power source, other electrical apparatus which must not fail.   95-238

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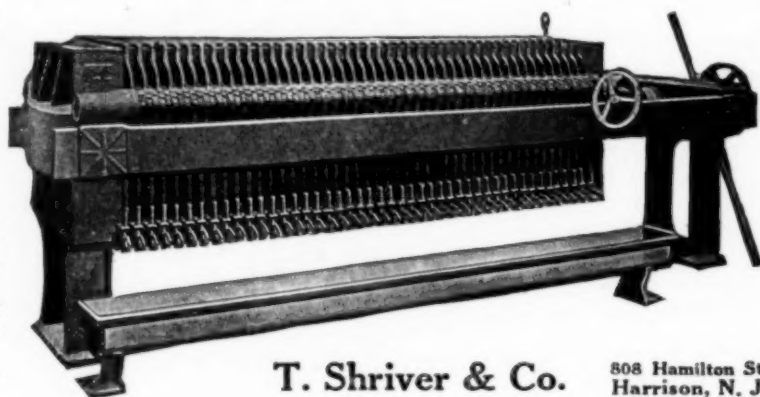
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The Federation's Washington Meeting

AS THE TIME approaches for the first meeting of the Federated American Engineering Societies and American Engineering Council in Washington, D. C., Nov. 18, 19 and 20, it becomes increasingly evident that an event of more than ordinary importance is about to transpire. We have endeavored consistently to support these new organizations through constructive criticism and suggestions. Among other points we have emphasized what must be almost self-evident, namely, that the success of the Federation will depend largely upon the number of constituent societies which decide to join. Impressive as a large aggregate membership may be, it is not so vital to the ultimate success of the Federation as the number of individual society members scattered throughout the country. It is gratifying, therefore, to learn that twenty-two societies have definitely cast their lot with the Federation; that eight more are now voting on the proposal and probably will send delegates to Washington. It is now certain that sixty-two delegates will be present, and when the meeting is called to order it is likely that the aggregate membership will be 50,000. Representing as they do engineers of all classes from all parts of the United States the member societies will give to the Federation and Council a potential force in engineering affairs that has never been equaled. Just how this force will be utilized and in what direction it will be exerted will be evidenced very largely in the first meeting of these bodies. In common with all engineers, therefore, we shall follow the proceedings hopefully and with deepest interest.

Making Progress Through Cleavage

THE ether of space enjoys all the rights and privileges of an imaginary thing. It is as elusive as a postulate in theology, for sometimes we have it—and then again we haven't. Some good men need it every hour and, like Sir OLIVER LODGE, find it a medium for the manifestation of departed spirits, while ALBERT EINSTEIN seems to get along pretty well without it. We have considered ether as having 450 times the density of platinum, and matter as therefore composed principally of holes in the ether; we have also regarded it as so airy and diaphanous that its qualities are "beyond numbers" and therefore over in the domain which is referred to by Sir EVELYN DE LA RUE as infinity; and again we have declared it to be *nil*.

Now comes Professor L. ZEHNDER, who reports, in the *Berichte der deutscher physischen Gesellschaft* (vol. 21, pp. 118-25, 1919), a hypothesis in which the ether is a substance whose ultimate particles consist of extremely small, perfectly elastic "ether atoms." These particles possess weight like ordinary atoms, but are relatively much smaller and have a velocity of the order of that of light. In spite of these enormous velocities every atom of an element has an etheral envelope, and so has every molecule. Then Professor ZEHNDER concludes that electricity is the *heat* of ether, that light is the *sound* of ether, while electric potential corresponds to the *temperature* of ether. The electron he holds to be an aggregation of a definite number of ether atoms. The hydrogen atom he believes to be spherical, and to consist of a globular elementary atom of completely elastic substance, surrounded by an ether envelope which is not completely elastic, since it consists of ether atoms compressed together, thereby giving rise to the existence of damped oscillations and ether motions. His views of the properties of ether, of radioactivity and of the problem of spectral lines are discussed at length in the paper.

It was just about 2,500 years ago that DEMOCRITUS formulated his atomic theory. All things he declared to be made up of atoms, and atoms were small, full, incompressible, without pores and homogeneous. They differed, however, in form, in position and in magnitude.

It has taken us 2,500 years to divide atoms into nuclei and electrons, and now Professor ZEHNDER wants electrons divided into atoms of ether. We have no objection. And if these units of ether are to constitute electrons by means of aggregation, then we would like to carve a niche in the temple of immortality for ourselves by suggesting that the units of ether also shall consist of still smaller parts which shall be endowed with whatever properties are needed. It's curious how ultimate particles seem invariably predestined to further subdivision—if we only wait long enough. If the particles we imagine do not carry on their surface the qualities we need, all we have to do is to carve them up to get new surfaces that were not there before. It is perfectly reasonable to do this.

Now we wonder—just wonder—how long this cutting up business will continue! Study leads to observation, and observation leads to the discovery of new principles —and then we cut up the particles to explain the principles. It would appear that the end is yet afar off, for in the understanding of nature we are still little more than children. There is a great deal yet to be observed, and it may be that in the future as in the past our only explanation will be to cleave the theretofore ultimate particles.

Another discussion that bids fair to outlast the youngest of us is the postulate of ether. Is there such a thing, or isn't there? Perhaps it is just as well not to be certain about it; not to pin our faith too firmly on an opinion. There was the phlogiston theory that held us in bondage for nearly two centuries. It was disturbing to progress.

Cause and Remedy
Of Fuel Shortage

OF COMMODITIES commonly employed in industry few if any have been as scarce as fuel. After selling for months at about ten times the price seen occasionally before the war, coal has become relatively plentiful in the market, but it is claimed that stocks in the hands of consumers are unusually light for the season of the year and that there is likely to be a severe "car shortage" this winter, producing a fresh and serious scarcity. Petroleum has been scarce and the outlook for future supplies is considered unpromising. Natural gas is being shut off from industries, to be conserved for domestic use, at the ascending prices domestic consumers are expected to pay gladly.

As to the relative importance of the three fuels, it may be mentioned that when comparison is made on the only basis possible, that of heat units shown by scientific tests, production in the past two or three years has been in approximately the following proportions: Coal, 85 per cent; petroleum, 11 per cent; natural gas, 4 per cent. Thus, apart from necessities of certain cases requiring a particular form of fuel, coal presents the great problem, from the mere viewpoint of the production of heat.

Why should the fuel problem jump to such great importance at this time? What is the matter? A long-range view furnishes the answer. The demand for fuel has increased so rapidly and continuously as to put it out of natural proportion. The sum total of human activity at any given time is so much. From decade to decade our population increases by about 20 per cent. The amount of work a man is willing to do in a day decreases instead of increases. Science and invention increase the man's efficiency, more than offsetting this, but leaving no great margin. The sum total of industrial results that the nation can accomplish probably increases by more than 25 per cent per decade, but it certainly does not increase by as much as 50 per cent. All lines of industrial activity, therefore, cannot increase by 50 per cent every decade. If circumstances favor one industry, it must be at the expense of some other industry.

Now look at coal. From a production of 320,072 tons in 1830 the output rose to six and one-half times as much in 1840, 2,070,039 tons. The next decade saw a multiplication by three and one-half, and it was not until 1850 to 1860 that there was merely a doubling. Every decennial year through 1890 saw more than a doubling. Then a doubling required a trifle over twelve years, to a time between 1902 and 1903. Next there was a doubling to a time between 1916 and 1917, or a 14-year interval.

A little industry can double all it likes, for it has a relatively inexhaustible field of men, materials and equipment from which to draw, but when an industry grows to such size as the coal industry it is another matter. People have other things to do than mine coal, and the railroads have a few other things to do besides hauling coal. The people would have no disposition to stop increasing their use of coal, if they could get it in any quantity desired and at prices to which they have been accustomed. The halt in the geometric progression had to be called some time, and now proves to be the time. The work put into the mining and transportation of coal cannot continue to increase much more rapidly than the sum total of our industrial accomplishment

increases. A collection of problems, in mining coal with less effort, in transporting fuel, heat or energy more efficiently and in consuming more economically, is therefore presented.

Seeing Ourselves as
The Cubans Might See Us

CUBA is about the richest country in the world. It has grown so rich that its wealth has taken on no less than a comedy character. Nearly every city contains a curious monument, usually in the form of a dwelling, of some hallelujah bumpkin who struck it rich and wanted to inflict the fruits of his own uncultured imagination in architecture upon the eyes of all beholders. The sale of patent leather shoes for feet theretofore bare has broken all records. There has been a veritable storm of diamonds and rubies and champagne on the island. Thousands of big sparklers emblazon collarless shirts. Bleary-eyed passengers on returning to this country have found themselves shouting for prohibition as an unexpected rebound from their days of cheer in Havana. Then the price of sugar went down and they have had to declare a moratorium in Cuba. Our good neighbors have been blowing in their money, and now they're in trouble. So we purse our lips and sink our chins into our collars and shake our heads and declare that they should have been more saving and thus avoided their present vicissitudes.

But how much better off are we? Have we saved? Have we been provident? Have we avoided debt when we could do it? Not so much as to make a very deep impression. Last year the people of the United States spent two billion dollars in luxuries, according to a recent statement of the Commissioner of Internal Revenue. That's about $20 a head, with wines and liquors cut out. We're still a long way off from "normalcy." The other day the writer of this stepped into an umbrella shop on Fifth Avenue to have a ferrule put on a stick. The price, which used to be twenty-five cents, was a dollar. "How much is that one?" we asked, pointing to one of dark wood that looked very plain and "conservative," as they call it. "That," said the clerk, "is $29.50. You see, the band is solid gold. With silver bands they run down to $15 or even $11 or $12." "And the price of that?" we asked, pointing to a plain one with no band at all. "This," said the clerk, taking it down and fondling it, "has been turned without taking the bark off, so you see what a beautiful grain it has under the varnish. It is a genuine malacca." "I see," said the visitor. "And how much is it?" "That stick is $40." "Whew! It does seem dear, doesn't it?" "Huh!" exclaimed the salesman. "A stick like that will last you all your life!" The public may have struck against high prices, but everybody doesn't know it yet. There is still a lot of easy money floating around, and easy money isn't good for us. It is bad for children, and no matter how old foreigners may be, most of us, the people of the United States, are still children.

Now that election is over it is time to quit boasting about ourselves and calling those persons bad names who don't vote as we do. When we bear in mind that every factory, every store, every railroad, every undertaking in progress, every development, is built and made with saving, it is but fair and right that we consider how important savings are. Every bank loan is made up of money set aside and saved by somebody or bodies. All the skyscrapers in New York were built with money

that was earned and saved. So is every establishment, big and little, built with the savings of the promoter or the stockholders, or the mortgagor or the depositor with the mortgagor—or all of them.

It is high time that those of us who have a little influence began to set the example of saving and then to preach its virtues. Pretty soon the value of money will increase again and the value of commodities and work will decrease. Then it will be very hard for those who have saved nothing and very comforting for those who have been provident.

Is Soundness in Steel Sacrificed to Tonnage?

AS AMERICANS we are accustomed to bigness— high mountains, wide rivers, great lakes, mighty forests, and open country. Our business and industrial life seems to have been cast in this mold. Favored with tremendous resources of raw materials, our steel industry, as an instance, has grown to perfectly extraordinary proportions, far outstripping in volume that of any other country. Considerations as to size are somewhat commonplace—we, as Americans, rather expect our undertakings to be big; but are we not also dangerously complacent as to the quality of these stuffs we produce in such huge tonnages?

Steam traction was invented and perfected in the United States. We also make tranverse-fissured rails— somehow, sometimes, no one knows why. Americans of ingenuity have designed fighting engines and defences of many types, yet when our steel men had to make them in quantity, a disease called "flakes" attacked the steel, and the doctors have not yet agreed upon the nature of the ailment, let alone proposed a specific. We build the biggest locomotives and the most automobiles, yet more lost time is chargeable to not quite good enough springs than to any other cause. Are we not more interested in volume of output than the excellence of the article in all its details?

Ten years ago there was a horrified outcry from the informed public about the deadly toll of rail failures, and spurred by this or their consciences, American steel makers turned anxious attention to their rail mills. Recent statistics show a most noteworthy improvement in service records; how this has been effected other than by careful attention to details has not been told, yet we suspect that even yet not enough attention is given toward producing sound ingots. Few would contest the statement, "a prerequisite to faultlessly finished material is perfect ingots"; fewer, unfortunately, have a realization that steel is very hot, is highly reactive, is delicate to handle, in fact is not *made*, until it has safely been cast into sound ingots.

But before venturing into a discussion of whether it is commercially possible to produce sound ingots it would be desirable to define the word "sound." "Sound" metal to one may mean an ingot which will roll into a salable product; to another, it may mean a casting without surface flaw or interior cavity, free of chemical segregation and non-metallic inclusions. Both represent the views of extremists. The first is a pernicious byproduct of a period when manufacturing profits are big enough to cover avoidable and profligate waste. The second is a hallucination of a cub inspector, comparatively harmless, even if bothersome.

Soundness may therefore be recognized as a comparative term. Absolute homogeneity in solidified steel is, by its very nature, impossible. Like most substances, it expands when it is heated and contracts on cooling; hot melted steel filling a mold to the brim will have considerably less volume when it has solidified, and consequently the mold will be full no longer. Hence pipes, contraction cavities and shrinkage cracks. It is idle to try to prevent the contraction demanded by nature's law; the best that can be done is so to control the formation of the resulting cavities that this type of defect is surely localized in a definite region.

Similarly, physical homogeneity is evidently impossible in a substance, like steel, solidifying over a wide range in temperature, by the fundamental law that a solid appearing from such a melt has a different composition than the mother liquor. Hence segregation. Even subsequent and drastic heat treatment which may be able to transport carbon over long distances is unable to equalize the distribution of slightly soluble or thoroughly insoluble substances such as sulphides or oxides—substances which are unquestionably normal constituents of steel, and doubtless always will be. Here again, by the very nature of things, the metallurgist is prevented from doing anything but so controlling natural laws that their effects will be felt in a predictable manner.

Despite these limitations, a definite and even precise conception may be had of the term "sound ingot metal." For our purposes it shall mean metal which has been so made, cast and cropped that if split it will be found free from visible cavities or cracks, a chemical survey will not show segregation greater than say 12 per cent of the heat analysis, and a microscopic study will not show quantities of oxidized inclusions.

Future progress toward the "soundness" represented by this definition will come from close observation of the natural properties of fluid steel as modified by the shape and construction of the molds, especially at the head, the temperature and method of pouring, and to a lesser extent but not less essential, the composition of the metal. That Americans can go far in this direction is apparent to every thoughtful observer of existing conditions, which can only be described as scandalous. Whether due to a purchasing public which is helpless, ignorant or impassive, or to makers who have hypnotized themselves into thinking that sound products are really not essential, or if they are they can be worked from spongy ingots, the fact remains that vast tonnages of beams, plates, rails and other shapes are made of ingots which no one, not an extremist, would call "sound." A steel salesman would also point out that this material is giving satisfactory service, and in the long run service is the master test. Satisfactory, *except* now and then! In rails alone these exceptions cause hundreds of casualties a year. Surely a weighty exception!

Rails are only an instance. That American metallurgists have suppressed their natural instincts for quality before production is at once a scandal and an indictment. Or is it that the "quantity-man" stands first in the eyes of big business? No matter. It was all very well as long as American steel was sold to Americans, who wanted trainloads of it cheap. But when the American market is saturated—and is it not becoming so?—big business will find it will have to make belated obeisance to the altar of quality, else the older worshipers from England and Continental Europe will romp off with all the foreign trade. Perhaps even the American public will become discriminating, if these pestiferous propagandists are not quieted somehow!

Gasoline Cracking Processes

Description of Commercial Methods for the Production of Gasoline by the Pyrolytic Distillation of Heavy Hydrocarbons, Including the Burton, Greenstreet, Hall, Rittman, Aluminum Chloride, Dubbs, Jenkins, and Bacon Processes—List of Inventors, Patent Numbers and Dates

By FRED W. PADGETT

IN A recent issue of this journal,[1] the phenomena of cracking of petroleum were discussed from their chemical aspects without regard to details involving the various commercial processes, which are the subject of the present paper. The writer does not wish to convey the impression that all the processes to be enumerated here are necessarily successful from a financial point of view, but they have in the main been used for the production of marketable gasoline.

The various processes for producing motor fuel from heavier hydrocarbons may be roughly classified as follows:

(1) *The Pressure Still.* A "two-phase" cracking system. Examples are the Burton and Coast processes.

(2) *The Pipe Still.* Generally a "one-phase" cracking system. Examples are the Greenstreet, Hall and Rittman processes.

(3) *The Use of Catalytic Agents at Atmospheric Pressure.* This may include reaction both in the "single-phase" and in the "two-phase" systems. An example is the aluminum chloride process, which is likely "two-phase" to some extent.

(4) *Combinations and Modifications of Two or More of the Above Methods.* The "cracking" may be in either "single-phase" or "two-phase" systems. Examples are the Dubbs, Jenkins and Bacon processes.

(5) *Processes Involving Principles Not Included Under the Above Four Headings, but Which May Involve Similar Apparatus or the Use of Pressure.* These methods may have either "single-phase" or "two-phase" cracking systems. Examples are the proposed processes of Cherry,[2] Coast,[3] Ellis[4] and many other processes, equally unique.[5] In the first, a bipolar, high-voltage, oscillating, silent electric discharge is passed through the vapors; in the second, hot gases are passed through the oil or into contact with oil spray; and in the third, air is supplied to the cracking chamber, where, by combustion of a portion of the oil, the heat necessary for the "cracking" of the remainder is generated.

During the past eight years numerous patents involving almost every conceivable form of apparatus have been granted for the purpose of securing hydrocarbons within the gasoline range from those of higher boiling point. Many of these patents seek to obviate the trouble incident to coke deposition, while others have the object in view of producing a gasoline which is comparable

in quality with the natural product. Still others are along entirely new lines.

As early as 1865, James Young, a Scotch industrial chemist, secured a patent for the production of illuminating oil by means of pressure at about 20 lb. to the square inch.

The apparatus of Benton for the production of illuminating oils from residual oils was patented in 1886, but was never used commercially. A pipe coil within a furnace is heated to a suitable temperature while the oil is forced through at a pressure of 285 lb. or more to the square inch. The products of the reaction are released into a vapor chamber, which in turn is in communication with a condenser. At the inlet end of the coil is placed a safety valve and at the outlet a stop cock for regulating the pressure on the coil.

In 1890, a patent was granted *Dewar and Redwood* for an apparatus involving design different from that of Benton. The process was intended for use in cracking Russian residual oil to illuminating oil, but was never applied commercially because of the demand for the starting material as fuel and its consequent rise in price. A retort disposed in a furnace has one end in communication with a dome, the latter also being connected to a condenser. Safety valve, pressure gage, charging line and receiver are also shown, and the condenser and receiver are held under pressure. It is proposed to fill the retort partially, to distill under pressure and to collect the distillate in the receiver. Dewar and Redwood do not state what pressure gives the best results.

THE BURTON PROCESS

Burton's first patent was granted in 1913, and the process is extensively used at the present time by the various Standard Oil companies. In 1918 it was estimated that 10 per cent of the gasoline produced was by cracking, a large proportion of this being through Burton stills. The development of this process marks one of the milestones in the history of petroleum refining and its originator merits the distinction of being the first to demonstrate that pressure distillation could be done safely and practically on a large scale. In addition, Burton realized the limitations of the type of apparatus and did not attempt, in the original design, to make the operation continuous.

The original claims of Burton consisted in the distillation of petroleum under a pressure of 4 to 5 atmospheres and a temperature of 650-850 deg. F., maintaining the pressure upon the volatile products until they had passed through the condenser.

The standard Burton apparatus includes a still of 200-bbl. capacity or more, of conventional shape, so constructed that high pressures may be used. Modifications of the Burton process call for introduction

[1] See CHEM. & MET. ENG., vol. 23, No. 11, Sept. 15, 1920, p. 521.
[2] U. S. Pat. 1,229,886, Jan. 12, 1917, and U. S. Pat. 1,327,023, Jan. 6, 1920.
[3] U. S. Pat. 1,252,401, Jan. 8, 1918, and Cosden-Coast, 1,261,215, April 2, 1918.
[4] U. S. Pat. 1,295,825, Feb. 25, 1919.
[5] Some of the principles involved are as follows: The use of molten metal as a cracking agent; oil may be sprayed against an electrically heated plate within an autoclave; a perforated basket charged with metallic turnings may be disposed in a furnace; oil vapors may be subjected to progressively increasing and then progressively decreasing temperatures; superheated steam; various methods utilizing electric discharge across vapors; emulsified oil as starting material; etc.

of the oil in the vapor line,[6] amounting to semi-continuous operation, the use of false bottoms[7] upon which the main portion of the carbon collects, and lastly a still of the water tube boiler type.[8]

At the present time the Standard Oil Co. of Indiana is operating three types of pressure distillation apparatus: (1) The Burton-Humphreys still; (2) the Clark apparatus; and (3) a later improvement of the original Burton-Humphreys modification involving the use of a special tower through which the vapors proceed before entering the water-cooled condensers. The first is generally operated intermittently or "batch," the latter two "semi-continuously"—i.e., oil is pumped in to replace that removed by distillation.

The arrangement of the vapor lines and receiving houses is of interest. The vapor lines from the Burton-Humphreys stills ascend gradually, terminating in manifolds which in turn connect with aërial condensers. During operation, vapors liquefied in the aërial condensers are continuously being refluxed to the stills. The uncondensed vapors from the aërial condensers enter the water cooled coils, where liquefaction takes place accompanied to some extent by solution of permanent gases in the distillate passing through the coils. From each water-cooled coil a "run line" terminates in an upright drum (gage glass at the side) which serves as a temporary receiver for the pressure distillate and also as a chamber for the separation of permanent gases not in solution in the distillate. A manifold constructed from small pipe connects together the tops of all the receiving drums in a battery of stills and serves the following important purposes: First, the equalization of pressure throughout the entire battery; second, the *control* of pressure on the stills in the battery (by means of a relief valve); and third, the withdrawal of permanent gases not in solution in the distillate.

The distillate in the receiving drums, consisting of from 50 to 60 per cent of the original charging material and yielding 50 to 55 per cent of gasoline upon subsequent fractionation in steam stills, is continuously withdrawn and collected in tanks at a pressure near that of the atmosphere. The gases which are produced during "venting" contain considerable quantities of gasoline vapor and may be treated by standard methods for gasoline recovery. The heavy residuum left after repeated "cracking" of the primary distillates heavier than gasoline and the primary residuums has a density approaching that of water and finds application as road oil.

It is claimed for the Burton process that by proper "rerunning" of primary residuum and heavy distillates in the pressure stills, 75 per cent of an oil, such as Oaklahoma crude, may be recovered as gasoline. For obvious reasons, however, this is not the customary practice.

THE DESIGN AND OPERATION OF PRESSURE STILLS

At the temperature at which the pressure still operates steel begins to decrease in tensile strength. Therefore, it is evident that a fundamentally important consideration lies in the material and method of construction of the stills.[9] As an outgrowth of this need there are now firms which specialize in the construction of stills for severe usage. The stills are solid metal $\frac{1}{2}$ to $\frac{3}{4}$ in. in thickness and hammer welded,[10] this method of construction being claimed as superior to both riveting and to acetylene or electric welding, for the purpose in view. In the operation of pressure stills the operator has before him thermometers and pressure gages, which inform him of the conditions prevailing within the various units under his control.[11] In the operation of some pressure stills using gas oil as the starting material, the distillation is continued at the average rate of 1 to 2 per cent an hour and the run is completed in 48 hours, giving a yield of 35 per cent of 450-deg. F. end point gasoline. During distillation the bottom of the still is watched if any "hot spots" develop, due to superheating from deposited carbon, and close surveillance is maintained to determine if it will be necessary to close down the still before the run is completed. After each run the deposited carbon is completely removed from the still before recharging.

During the operation of pressure stills, the proper distribution of heat on the bottoms of the still is important. Between operating periods it is customary to inspect the apparatus carefully at all points and often to measure the thickness of the metal so that the amount of corrosion, due to sulphur compounds in the oil, may be ascertained.

THE GREENSTREET PROCESS[12]

The first patent in this process was granted to the applicant in 1912,[13] and a plant of this design has been in operation in St. Louis for a number of years. By this method the oil vapors are subjected to heat while traversing tubes in the presence of steam. The oil to be treated is first forced through preheater coils so arranged in the furnace that a very high temperature is not secured. The oil is then mixed with steam and enters the cracking coils, where the vapors are subjected to the most severe temperature conditions in the entire cycle. From the cracking zone the products leave the coil and enter drums of considerable size where the velocity of the vapors is lessened, the heavier constituents condense, while cracking and polymerization continue for a longer time than otherwise would be the case. Leaving the expanding drums, the lighter vapors are reduced in pressure before they enter the condenser. The heavier products are drawn off from the bottom of the expanding drums.

THE DESIGN AND OPERATION OF PIPE STILLS FOR CRACKING

In the Greenstreet process the cracking coil units are of 2-in. pipe 425 ft. in length, six or more of which are arranged in the furnace to make up the complete installation. These coils are suspended from steel beams at the top of the furnace in a way that facilitates easy removal and replacement. The furnace is operated by a stillman who has before him gages, meters and thermometers for noting the conditions prevailing in the process. When operating pipe stills in the presence of steam[14] for the production of motor fuel from heavier hydrocarbons, the rate of flow, temperature, pressure and quantity of steam depend upon the character of the initial material. Thus kerosene would neces-

[6]U. S. Pat. 1,199,464, Sept. 26, 1916.
[7]Humphreys patents 1,122,002 and 1,122,003, Dec. 22, 1914 and 1,119,700, Dec. 1, 1914.
[8]Clark patents 1,119,496, Dec. 1, 1914; 1,129,034, Feb. 16, 1915, and 1,132,163, March 16, 1915.
[9]See, in this connection, the work of Bjerregaard, *J. Ind. Eng. Chem.*, vol. 7 (1915), p. 573.

[10]U. S. Jenkins in the construction of his apparatus utilizes a combination of riveting and electric welding at the joints on the inside. The metal is $\frac{3}{4}$ in. in thickness.
[11]Liquid meters are sometimes placed on the run lines.
[12]*Petroleum Age*, vol. 6 (1919), p. 66.
[13]English Patent, 16,452, July 13, 1912.
[14]Private communication.

sitate the use of less steam, but a higher pressure and temperature, than gas oil, to secure the best results. In operating pipe stills for cracking, it is considered necessary to determine optimum operating conditions for a particular type of starting material, and then to adhere as strictly as possible to these conditions during subsequent runs. "Close cut" distillates are said to give the best results.

THE HALL PROCESS

Although developed by an American, this process was first tried on a commercial scale in the British Isles, being used throughout the war for the production of benzol and toluol from gas oil. In this country the Texas Company has been interested in the process and has done considerable research, but at this time has no information which it wishes to make public. The apparatus, in a broad way, resembles that of Greenstreet, but has the fundamental difference of operation in that steam is not used. The operation of one of Hall's British plants was described by Lomax in 1916, but since Hall has been a prolific inventor, especially on methods of treating the distillates secured, it is possible that important changes have been incorporated in the commercial operation since that time.

It has been reported that the Hall process is being used to "crack down" heavy Mexican crude to a suitable viscosity for use as fuel.

The oil[15] traverses the coil and is gradually heated until the most severe conditions are encountered at the outlet where the pressure is reduced to near atmospheric, the speed of the vapors reaching 5,000 to 6,000 ft. per minute. From the expanding drum the vapors pass through a series of dephlegmators where several products of varying boiling point are removed and finally to a compressor where the vapors are compressed and then cooled. Each coil is composed of 600 ft. of cold-drawn 1-in. (internal diameter) tubing, and the coils are spoken of as being arranged in nests.

For the production of motor fuel a temperature of 550 deg. to 600 deg. C. obtains at the tube outlets (pressure, 75 lb.), but in working for benzol a temperature of 750 deg. C. and pressures of 100 to 105 lb. to the square inch are necessary. No doubt these conditions will vary for various types of starting materials. It is claimed that motor fuel to the extent of 70 per cent can be secured from the total original oil charged, by rerunning certain residues from the dephlegmators.

THE RITTMAN PROCESS[16]

So many are familiar with the principles of this method that a detailed description is unnecessary here. Suffice it to say that the "cracking" takes place in the vapor form in an upright tube. Oil is atomized into the tube at the top and the gasoline vapors and tar are taken off separately from the tar pot at the bottom. Carbon is removed from the sides of the tube in the cracking zone by means of a rod and chain, the latter being thrown against the sides when the former is revolved. Optimum conditions for operation are given as follows by Rittman and Dean: for gasoline 500 to 550 deg. C. and a minimum of 12 atmosphere pressure; for the production of aromatics a temperature of 625 to 700 deg. C., and a minimum pressure of 8

atmospheres are recommended. A single tube of the Rittman type is specified by Bowie as 13 to 14 in. in diameter and 13.5 ft. in length.

THE ALUMINUM CHLORIDE PROCESS[17]

The most conspicuous developments under this method have been carried out by McAfee[18] of the Gulf Refining Co. The oil is heated and stirred in a still in the presence of anhydrous aluminum chloride or other anhydrous salt of aluminum. Before treatment the oil must be freed from water and a quantity of the catalyst equal to a maximum of 8 per cent by weight of the oil charged is added before the distillation is begun. Fractionating towers are interposed between the still and the condenser so that the higher boiling vapors may be returned to the still along with aluminum chloride which has been vaporized and carried out. The distillation is continued slowly at a temperature of 500 to 550 deg. F. over a period of 24 to 48 hours. By this method, a yield of gasoline of 15 per cent or more may be obtained from residual oils.

Very interesting in connection with this process is the effect upon the residue remaining in the still and the character of the distillate secured. At the end of the distillation it is found that the aluminum chloride is enclosed in granular coke, which is easily removed, and that a heavy oil free from asphalt, its viscosity in no way impaired by the procedure, may be separated from the coke and then utilized for the production of high-grade lubricating oils, the recovery of paraffine wax or the manufacture of petrolatum. The distillate secured by aluminum chloride treatment is water white, possesses a pleasant odor and in order to secure the finished gasoline it is only necessary to wash the "re-run" distillate with dilute alkali and water.

By the action of anhydrous aluminum chloride on residual petroleum, sulphur compounds are destroyed and possibly nitrogen and oxygen compounds such as naphthenic acids as well.

The one difficulty suggesting itself as being inherent in this process is that of recovering the aluminum chloride, or of manufacturing it cheaply.

OTHER PROCESSES

Three methods which have recently come into prominence because of favorable reports concerning their operations are those of Dubbs, Jenkins and Bacon.

The design and operation of the *Dubbs plant* is given in the report of a committee of the Western Refiners' Association to its members. Extracts from this report are quoted as follows: The plant proper consists of a cracking coil made up of ten lengths of 4-in. extra heavy lapwelded pipe, each 20 ft. in length, joined on the ends by return bends. This coil of 4-in. pipe is located horizontally in a furnace in two rows, six of the pipes being in the lower row and four in the upper row. The furnace temperature is maintained at approximately 1,540 deg. F. The outlet of the 4-in. coil is connected to an expansion chamber, which consists of four 20-ft. lengths of 10-in. common extra heavy pipe. These pipes are connected in series by return bends so as to form an expansion chamber approximately 80 ft. long. These 10-in. pipes are located horizontally in a chamber and are not heated, but lagged to prevent loss of heat by radiation.

[15]Lomax, *J. Inst. Pet. Tech.*, vol. 3 (1916), p. 36.
[16]See U. S. Bureau Min. Bulletin 114 and Technical Paper 161.

[17]See *J. Ind. Eng. Chem.*, vol. 7 (1915), p. 737.
[18]*Ibid.*

The raw oil is fed into one end of the 4-in. coil by means of a force pump, and as the oil passes through, it is heated to about 820 deg. F. and is then discharged from the other end into the 10-in. expansion pipes, which are maintained approximately half full of oil. The vapors are liberated from the oil and pass up through connecting goosenecks to a manifold, then to vapor lines leading to a spiral vapor condenser and finally into a water-cooled condenser. A pressure of about 135 lb. to the square inch is maintained on the entire apparatus. The unvaporized portion of the oil in the 10-in. coil is continuously drawn off from the end of the last unit.

In regard to the Dubbs process, it should be noted that the "cracking" takes place in a "two-phase" system.

The results of a test run of 168-hr. duration are summarized as follows:

Total gas oil treated, gal. 20,952
Total uncondensable gas, cu.ft. 25,851
Fuel used [19]—equivalent of 3,677 gal. of 14 Bé. fuel oil.

Products (per cent yield of original oil charged):	Per Cent
Gasoline (440 end point), (58-59 deg. Bé.)	26.29
Kerosene (40-41 deg. Bé.)	14.11
Pressure distillate bottoms (31-32 deg. Bé.)	27.19
Residuum (13-14 deg. Bé.)	24.71
Loss	7.70

The principle of the *Jenkins process* is the use of an apparatus resembling the water-tube boiler. The tubes in the latest installation are 2½ in. outside diameter, and cold drawn. The furnace is of the vertical baffle type with Dutch oven, no heat coming in direct contact with either the longitudinal or transverse drums. The operation of the process is continuous and the oil is circulated mechanically. The safe limit of operation (with the type of starting material being used) has been found to be when a volume of oil equal to fourteen times the charging capacity has been passed into the apparatus. Working under these conditions, it is claimed that the life of the still is greatly prolonged and that the time of cleaning is five minutes per tube. In closing down after a run the reduction of temperature is accomplished gradually by forcing more charging oil into the apparatus under complete mechanical circulation, thus eliminating undue stresses or strains which might be caused by a sudden temperature drop. Mr. Jenkins contributes the following data in connection with a run of 46 hours, using pressure distillate gas oil[20] from Homer crude as the starting material:

Total oil circulated, gal. 17,130
Overhead pressure distillate, gal. 11,600
Fuel used—48,000 cu.ft. of city gas (natural).

Products (per cent yield of original starting material):	Per Cent
Gasoline (118 i.b.p., 460 end point)	24
Kerosene	29
Steam still bottoms	14
Pressure still bottoms (52 vis. Saybolt at 100 deg. F. and when treated, 4-½ color)	27
Total loss	6

The pressure used in the above run varied from 105-110 lb. gage; temperature 700-710 deg. F.

THE BACON PROCESS

The Bacon process was developed under the direction of Raymond F. Bacon and Benjamin T. Brooks at the Mellon Institute of Industrial Research. As originally designed, some difficulties were encountered during operation because of coke deposition on the tubes but, according to the latest information, certain improvements have made the process appear very

promising. The "cracking" is carried out in vertical tubes 20 ft. in length and 6 to 19 in. in diameter, the oil level being maintained at the top of the heated zone, and the process operated continuously. The oil inlet and vapor outlet are located at the top of the tube. The lower ends of the tubes are connected to a drum into which the tar and coke settle and are drawn off from a pipe at the bottom. When operating an apparatus of this type, coke accumulates very slowly on the metal surface in the cracking zone and in addition a large heating surface is exposed to the oil. The pressure specified is from 60 to 300 lb. to the square inch, but preferably 100 lb. The yields of gasoline (56 Bé.) claimed for various oils are as follows:

	Per Cent
Oklahoma gas oil (32 deg. Bé.)	45
Mexican fuel oil (12 deg. Bé.)	50
California fuel oil (14 deg. Bé.)	47
Caddo heavy crude (12–14 deg. Bé.)	48

THE PRESENT STATUS OF THE PETROLEUM "CRACKING" INDUSTRY

While the past eight years has seen an enormous amount of research and invention along this line, the present finds but few which may safely be designated as established processes. A conclusion which is soon reached is that no matter how promising a process may appear at the beginning, only extended plant operation determines its commercial success. The operation of the pressure still is approaching something like standard practice in many refineries, but even then has its limitations. Some time ago one optimistic refiner informed the writer that he had directed his research staff to bend its energies toward the discovery of a chemical agent, either catalytic or otherwise, which would transform all, or nearly all, of the heavy hydrocarbon mixture into gasoline, with only negligible loss due to coke and gas formation. However difficult this may be, such a course would seem to be the most legitimate in view of the results in the past ten years along other lines.

In the field of pure research it is desirable that the problem of the composition of petroleum be undertaken in a broad way and with sufficient funds and personnel to insure the solution of the problem within a reasonable time. In the past this work has been handicapped, not by the lack of expert or enthusiastic direction, but by the need of more extended facilities. Such routine work as fractional distillation consumes a great deal of time.

The need of research upon the properties of the higher members of the hydrocarbon series other than the aromatics has been emphasized by Brooks[21] and needs no discussion here.

A Select List of Patents on Cracking

Abel, British 4,769, 1877.

Adams, J. H., U. S. 1,327,263, Jan. 6, 1920; U. S. 1,320,-354, Oct. 28, 1919.

Adams, A. B., British 119,485, July 5, 1917; French 486,312, March 22, 1918.

Alexejew, G., German 39,949, Jan. 20, 1887.

Andrews, B., and Averill, W. C., U. S. 1,320,354, Oct. 28, 1919; U. S. 1,319,828, Oct. 28, 1919.

Anderson, W., and Meekle, J., British 108,508, Aug. 4, 1916.

Bacon, R. F., Brooks, B. T., and Clark, C. W., U. S. 1,131,309, 1915; U. S. 1,334,731, March 23, 1920.

Bacon, R. F., and Clark, C. W., U. S. 1,101,482, June 23, 1914.

Barbet, E. A., French 380,282, Oct. 3, 1906; French 390,558, July 31, 1907.

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[18]Consumed during the run.
[20]It should be noted that this starting material has already been once through the process.

[21]CHEM. & MET. ENG., vol. 22 (1920), p. 933.

Bell, A. F. L., U. S. 1,231,695, July 3, 1917.
Benton, G. L., U. S. 342,564, May 25, 1886; U. S. 342,565, May 25, 1886.
Bergius, F., Austrian 71,298, June 26, 1916.
Biggins, J. E., U. S. 1,274,976, Aug. 6, 1918.
Born, S., U. S. 1,234,124, July 24, 1917.
Brownlee, R. H., U. S. 1,308,161, July 1, 1919; Can. 185,052, June 25, 1918.
Burke, British 16,931, 1911.
Burton, W. M., U. S. 1,105,961, Aug. 4, 1914; Can. 155,-567, May 12, 1914; U. S. 1,167,884, Jan. 11, 1915; U. S. 1,049,667, Jan. 7, 1913.

Cassall, C. E., and N. C., and Gerraus, B. H., British 117,087, June 29, 1916.
Cherry, L. B., U. S. 1,327,023, Jan. 6, 1920; U. S. 1,229,-886, June 12, 1917; British 104,330, Dec. 1, 1916.
Clark, E. M., U. S. 1,132,163, March 16, 1915; U. S. 1,129,-034, March 16, 1915; U. S. 1,119,496, Dec. 1, 1914; British 1,424, Jan. 28, 1915.
Cleveland Trust Co., British 134,567, April 24, 1918.
Cobb, E. B., U. S. 1,322,762, Nov. 25, 1919.
Coast, J. W., Jr., U. S. 1,252,999, Jan. 8, 1917; U. S. 1,252,401, Jan. 8, 1918; U. S. 1,258,190, March 5, 1918; U. S. 1,258,191, March 5, 1918; U. S. 1,250,800, Dec. 18, 1917; U. S. 1,250,801, Dec. 18, 1917; U. S. 1,250,799, Dec. 18, 1917; U. S. 1,250,798, Dec. 18, 1917; U. S. 1,291,414, Jan. 14, 1919; U. S. 1,307,724, June 24, 1919.
Cochran, A., U. S. 1,296,367, March 4, 1919.
Cosden, J. S., and Coast, J. W., Jr., U. S. 1,261,215, April 2, 1918; U. S. 1,258,196, March 5, 1918.
Continental Caoutchouc & Guttapercha Co., British 7,112, 1913; Swedish 41,840, Jan. 10, 1917.
Cross, W. M., U. S. 1,326,851, Dec. 30, 1919.
Cross, R., British 126,103, April 3, 1918; U. S. 1,255,138, Feb. 5, 1917.
Court, J. W., Can. 184,279, May 14, 1918.
Cowper-Coles, British 27,945, 1906.

Day, U. S. 826,089, 1906.
Day, D. T., MacDonald and Day, R. B., British 113,264, Nov. 16, 1917.
Day, R. B. and D. T., U. S. 1,280,179, Oct. 1, 1918; British 119,440, Nov. 16, 1917.
Day, R. B., British 120,230, Sept. 27, 1917.
Day, D. T., U. S. 1,221,698, April 3, 1917.
Dampierre, M. A. H., French 20,331, Aug. 1, 1917; British 109,796, Aug. 15, 1917; French 478,831, Jan. 12, 1916.
Danckwardt, P., U. S. 1,141,529, June 1, 1915.
Davidson, J. G., and Ford, R. W., U. S. 1,229,042, June 5, 1917.
Deakin, British 708,496, Aug. 16, 1916.
Dewar, J., and Redwood, B., U. S. 419,931, Jan. 21, 1890; U. S. 426,173, April 22, 1890; British 10,277, June 24, 1889.
Dubbs, U. S. 1,319,053, Oct. 21, 1919.
Dubbs, J. A., U. S. 1,100,717, June 23, 1914; U. S. 1,135,506, April 13, 1915.
Dubbs, C. P., British 112,010, Oct. 31, 1917; U. S. 1,231,509, June 26, 1917.
Dundas, R. C., U. S. 1,257,199, Feb. 19, 1918.

Edwards, J. B., U. S. 1,277,881, Sept. 3, 1918.
Ellis, C., U. S. 1,295,825, Feb. 25, 1919; U. S. 1,216,971, Feb. 20, 1917; U. S. 1,249,278, Dec. 4, 1917; U. S. 1,318,060, Oct. 7, 1919; British 25,631, Nov. 8, 1912.
Ellis, C., and Foster, N. L., British 121,356, Dec. 15, 1917.

Fenchelle, H. E., and Perkin, F. M., British 6,547, March 14, 1914.
Fleming, R., U. S. 1,324,766, Dec. 9, 1919; British 135,-854, Nov. 26, 1919; U. S. 1,325,668, Dec. 23, 1919.
Forward, C., French 481,494, Dec. 8, 1916; U. S. 1,189,-083, June 27, 1916.
Forward, G. F., and Taplay, J. G., British 133,059, Dec. 12, 1916; British 128,255, July 3, 1917.
Forward, G. F., British 103,572, April 7, 1916.
Franke, British 13,261 and 15,459, 1913; British 18,226, Aug. 1, 1914.

Gasoline Corporation, British 115,014, Aug. 3, 1917.
Govers, F. X., U. S. 1,297,833, March 18, 1919.
Graefe, E., and Walther, R. V., British 25,510, Nov. 7, 1913.
Gray, G. W., British 17,838, Aug. 5, 1913; British 17,839, Aug. 5, 1913; U. S. 1,193,541, Aug. 8, 1916; Holland 2,003, June 15, 1917; U. S. 1,193,540, Aug. 8, 1916.
Gray, J. L., Can. 153,966, Feb. 24, 1914; U. S. 1,331,909, Feb. 24, 1920.
Greenstreet, U. S. 1,299,172, April 1, 1919; U. S. 1,166,-982, Jan. 4, 1916; British 16,452, July 13, 1912; French 462,484, 1913; U. S. 1,110,923, Sept. 15, 1914; U. S. 1,110,-

925, Sept. 15, 1914; U. S. 1,110,924, Sept. 15, 1914; British 17,057, July 22, 1912.

Hall, British 17,121, 1913; British 16,857, July 15, 1914; British 24,491, 1913; British 103,720, March 4, 1916; U. S. 1,175,909, March 14, 1916; U. S. 1,194,289, Aug. 8, 1916; French 467,381, 1914; British 7,282, 1914; British 12,962, 1914; British 6,069, April 22, 1916; U. S. 1,175,910, March 14, 1916; British 8,836, June 15, 1915; U. S. 1,285,136, Nov. 19, 1918; U. S. 1,239,099, Sept. 4, 1917; U. S. 1,261,930, April 9, 1918; U. S. 1,242,796, Oct. 9, 1917; British 4,598, March 24, 1915; British 2,948, Feb. 4, 1914; British 1,594, Feb. 1, 1915.
Hall, W. A., U. S. 2,661, Oct. 15, 1918; U. S. 1,247,671, Nov. 27, 1917; U. S. 1,239,100, Sept. 4, 1917; U. S. 1,242,795, Oct. 9, 1917; U. S. 1,242,796, Oct. 9, 1917.
Hall Motor Fuel Co., Ltd., French 481,066, Oct. 27, 1916; French 483,231, June 13, 1917.
Higgins, W., and Preston, C. H., British 23,876, Dec. 10, 1914.
Hill, R. L., U. S. 1,269,439, June 11, 1918.
Hirshberg, L., and P. D. L., British 4,573, Feb. 21, 1914.
Hirt, L. E., U. S. 1,250,879, Dec. 18, 1918.
Holmes, J. E., U. S. 1,241,979, Oct. 2, 1917.
Hopkins, A. S., Can. 174,332, Jan. 2, 1917; U. S. 1,199,-463, Sept. 26, 1916; U. S. 1,199,464, Sept. 26, 1916; Can. 174,333, Jan. 2, 1917.
Hubbard, U. S. 1,326,056, Dec. 23, 1919.
Humphreys, R. E., U. S. 1,122,003, Dec. 22, 1914; U. S. 1,122,002, Dec. 22, 1914; U. S. 1,119,700, Dec. 1, 1914.
Hyndman, H. M., French 462,484, Sept. 11, 1913.
Hydrocarbon Oil Co., Holland 1,979, May 15, 1917.

Iroline Co., British 3,327, March 2, 1915.
Isom, E. W., U. S. 1,285,200, Nov. 19, 1918.

Jenkins, U. S., U. S. 1,226,526, May 15, 1917; French 485,774, Feb. 6, 1918; U. S. 1,321,749, Nov. 11, 1919; British 116,119, May 17, 1917.
Jones, A. R., U. S. 1,328,522, Jan. 20, 1920.
Jones, H. W., U. S. 1,336,357, April 6, 1920.

Kittle, H. A., British 8,336, April 6, 1909.
Koetschau, U. S. 1,325,299, Dec. 16, 1919.
Kormann, F. A., U. S. 1,332,849, March 2, 1920.

Laing, John, British 4,120, March 17, 1890; British 11,757, July 28, 1890.
Lambert, C. G., U. S. 1,245,930, Nov. 6, 1917.
Lamplough, U. S. 1,229,098, June 5, 1917.
Lamplough, F., British 19,702, Aug. 28, 1912; British 28,101, 1912; British 16,830, Nov. 30, 1915; French 457,877, 1913.
Landes, W., British 107,502, Oct. 11, 1916; U. S. 1,199,-909, Oct. 3, 1916.
Leffer, L. G., British 2,328, Jan. 29, 1912; British 19,051, Aug. 20, 1912; British 4,140, Feb. 18, 1913; French 439,476, Jan. 29, 1912; French 454,580, 1913.
Lewis, G. P., French 481,771, Jan. 16, 1917; British 7,535, May 19, 1915.
Low, F. S., U. S. 1,192,653, July 25, 1916.
Lucas, U. S. 1,183,091, May 16, 1916.
Lucas, O. D., U. S. 1,168,404, Jan. 18, 1916.
Luck, C. E. C., British 12,059, May 23, 1913.

Mann, F. W., and Chappell, M. L., U. S. 1,249,444, Dec. 11, 1917; U. S. 1,257,906, Feb. 26, 1918.
Maxim, D. S., British 128,227, June 15, 1916.
McAfee, A. M., U. S. 1,099,096, June 2, 1914; U. S. 1,144,304, June 22, 1915; British 22,244 and 22,243, Nov. 9, 1914; British 22,922, Nov. 23, 1914; British 22,923, Nov. 23, 1914; U. S. 1,326,072, Dec. 13, 1919; U. S. 1,277,329, Aug. 27, 1918; U. S. 1,326,073, Dec. 23, 1919; U. S. 1,235,523, July 31, 1917.
McComb, W. M., U. S. 1,337,144, April 13, 1920.
Miller, J. R., U. S. 1,312,265, Aug. 5, 1919.
Moeller and Wolterek, British 16,611, July 19, 1913.
Montague, H. E., U. S. 1,227,551, May 22, 1917.

Nelson, J., British 116,304, March 13, 1917.
New Oil Refining Pro., Ltd., British 20,074, Sept. 3, 1912; also 20,075.
New Process Oil Co., French 478,316, Dec. 3, 1915.
Noad and Townsend, British 13,675, 1908.

Oltmans, J., British 108,454, Jan. 2, 1917.

Palmer, U. S. 1,187,380, 1916.
Palmer, C., U. S. 1,313,009, Aug. 12, 1919.
Parker, W. M., U. S. 1,226,990, May 22, 1917; Can. 176,-344, April 10, 1917.
Parker, J. H., U. S. 958,820, May 24, 1910.
Parker Process Co., French 483,453, July 11, 1917.

Payne, T., British 119,066, Sept. 6, 1917.
Phillips and Bulteel, British 23,977, 1909.
Planes, Ltd., and Thompson, W. P., British 5,245, March 1, 1913.
Porges, P., etc., British 11,420, May 8, 1914.

Ragos'n, V. T., British 1,411, Jan. 18, 1898.
Ramage, A. S., Can. 179,252, Sept. 11, 1917.
Renard, G., British 3,413, Feb. 10, 1913; French 462,286, Sept. 8, 1913.
Rittman, W. F., British 9,162, June 22, 1915; British 9,163, June 22, 1915.
Rittman, W. F., and Whitaker, M. C., Danish 23,464, Sept. 2, 1918.
Robertson, J. G., and Nelson, J., etc., British 10,981, July 29, 1915.
Robertson, J. H., U. S. 1,238,339, Aug. 28, 1917.
Rollason, British, 18,490, Aug. 10, 1914.
Rosenbaum, R. R., U. S. 1,324,938, Dec. 16, 1919.
Rostin and Forwood, British 107,034, May 15, 1916.
Roth and Venturino, M. E., British 106,042, Sept. 20, 1916.
Roth and Venturino, M. E., British, 123,151, Feb. 12, 1918.
Rubexksche, Montanwerke, German 37,728, Dec. 29, 1886.
Ruff, F. C., U. S. 1,325,582, Dec. 23, 1919.

Sabatier, French 400,141, 1908.
Sabatier, and Mailhe, A., U. S. 1,152,765, Sept. 7, 1915; U. S. 1,124,333, Jan. 12, 1915; British 16,791, July 14, 1914; U. S. 1,152,765, Sept. 7, 1915.
Schmidt, W. A., and Walcott, E. R., U. S. 1,308,161, June 24, 1919; U. S. 1,307,931, June 24, 1919.
Schwartz, S., U. S. 1,247,883, Nov. 27, 1917.
Seeger, R., U. S. 1,259,786, March 19, 1918.
Seigle, A., U. S. 567,751, Sept. 15, 1896; U. S. 567,752, Sept. 15, 1896.
Shedlock, etc., British 1,878, Jan. 23, 1914; French 475,303, 1914.
Simplex Refining Co., French 480,147, June 22, 1916.
Sinclair Refining Co., British 128,806, Sept. 12, 1918.
Slocum, F. L., and Stutz, C. C., U. S. 1,304,211, May 20, 1919; U. S. 1,304,212, May 20, 1919.
Smith, A. D., U. S. 1,324,075, Dec. 9, 1919; U. S. 1,239,423, Sept. 4, 1917.
Snelling, W. A., French 480,899, Oct. 4, 1916; British 18,419, Aug. 7, 1914.
Soc. Synthetic Hydro-Carbon Co., French 479,210, March 1, 1916.
Standard Oil Co., British 29,862, 1912; Austrian 71,429, March 27, 1916; French 469,689, 1914; Norwegian 26,825, April 3, 1916; U. S. 1,055,707, 1913; British 1,226, Jan. 26, 1915; Can. 155,567, 1914; British 6,593, 1914; U. S. 1,049,667, 1913; U. S. 1,119,700, 1914; U. S. 1,122,002, 1914; U. S. 1,122,003, 1914; French 476,882, 1914; British 21,273, Oct. 20, 1914; British 7,541, 1915; British 1,226, 1915; U. S. 1,132,163, 1915; French 477,829, Feb. 27, 1915; French 477,404, 1915; Norwegian 26,668, Feb. 14, 1916; Danish 21,088, March 3, 1916.
Stapp, A. A., U. S. 1,324,212, Dec. 9, 1919; U. S. 1,324,213, Dec. 9, 1919.
Synthetic Hydrocarbon Co., British 108,333, June 29, 1916; British 17,822, Dec. 20, 1915; Swiss 75,773, Sept. 17, 1917; Danish 23,052, April 29, 1918.

Testelin and Renard, British 16,881, 1908; U. S. 1,138,260, May 4, 1915.
Thompson, W. P., U. S. 1,160,670, Nov. 16, 1916.
Todo, P., Japanese 32,460, March 29, 1918.
Trumble, M. J., U. S. 1,281,884, Oct. 15, 1918.
Turner, C. W., U. S. 1,046,683, Dec. 10, 1912; British 25,832, Nov. 11, 1912; French 451,162, 1912.

Valpy and Lucas, British 12,653, Jan. 22, 1914; British 20,470, Sept. 10, 1913.
Von Groeling, A. F., etc., British 16,713, July 13, 1914; British 10,213, April 30, 1913; U. S. 1,295,088, Feb. 18, 1919.

Wade, H. C., U. S. 1,336,450, April 13, 1920.
Washburn, C. H., U. S. 1,138,266, May 4, 1915.
Wassmer, British 26,936, 1909.
Wellman, F. E., U. S. 1,335,767, April 6, 1920; U. S. 1,335,768, April 6, 1920; U. S. 1,335,769, April 6, 1920; U. S. 1,275,337, Aug. 13, 1918; U. S. 1,335,771, April 6, 1920; U. S. 1,335,772, April 6, 1920; U. S. 1,335,773, April 6, 1920; U. S. 1,335,774, April 6, 1920; U. S. 1,245,291, Nov. 6, 1917.
Wellman, F. E., and Sibley, F. H., U. S. 1,335,770, April 6, 1920.
Wells, A. A., U. S. 1,187,874, June 20, 1916; U. S. 1,248,225, Nov. 27, 1917; U. S. 1,232,454, July 3, 1917.
Wheatcroft, I. H., British 111,317, Nov. 6, 1916.

Whitaker, M. C., and Rittman, W. F., U. S. 1,327,001, Jan. 6, 1920.
White, C., British 5,434, March 3, 1914; French 477,771, Feb. 23, 1915.
Winget, J. N., U. S. 1,229,189, June 5, 1917. 1916.
White, L., and Kellar, C. F., British 105,256, April 1, 1916.
Young, J., British 3,345, Dec. 27, 1865.
Zerning, H., U. S. 1,183,266, May 16, 1916.
Zerning, H., British 731, Jan. 9, 1913.

Wave Power Transmission
FROM OUR LONDON CORRESPONDENT

London, Oct. 13, 1920.

The formulation of a new and practical method for the transmission of energy is a rare occurrence, and the announcement just made by W. H. Dorman & Co., Ltd., of Stafford, seems to be of far-reaching importance to the mining, shipbuilding and allied industries. The principles of the transmission of power by wave impulses through liquids were necessarily kept secret during the war owing to their use for the automatic firing of guns on airplanes and like purposes. Since the armistice, wave power tools have reached a high state of development and the opinion is generally held that in the mining industry particularly sweeping economies are to be expected by the adoption of this system in place of compressed air.

Briefly the apparatus consists of a wave generator comprising one or two metal cylinders each fitted with a piston driven by any suitable high-speed prime mover and a corresponding wave motor at the far end of the transmission pipe line. The pistons at the wave motor end are suitably connected to the tool or other mechanism to be operated, such as a rock drill, riveting hammer or rotary mechanism, the energy being transmitted through the pipe line in the form of a succession of power waves rendered possible by the slight compressibility of the water or other liquid medium and to a smaller extent by the slight expansion of the pipe line under pressure. The mean pressure in the pipe line for rock drill work is about 750 lb. per sq.in., but the special ball-jointed pipe lines are tested to 15,000 lb. per sq.in. It is claimed that an over-all mechanical efficiency of 50 per cent is attained as against 10 per cent with compressed air, while maintenance costs are one-third and capital costs one-half those obtaining in compressed air work. The usual "frequency" is 2,400 waves or blows per minute and the use of springs and the presence of air at the drill point are eliminated. Lubrication in unnecessary and existing standard appliances can be converted to the new system. The extension of this method of energy transmission is foreshadowed in regard to piledriving, coal cutting, oil conveyors and other industrial applications.

Production of Potash in Alsace—Correction

In our issue of Sept. 1, 1920, p. 382, we published an excerpt from the June 30, 1920, number of the *Frankfurter Zeitung* stating that during 1919 Alsace produced 40,000 metric tons of potash.

H. J. Baker & Bros. of New York inform us that their principals, the Société Commerciale des Potasses d'Alsace, have brought to their attention the fact that this figure is not correct and that the actual figure for potash produced by Alsace mines for the year 1919 was 92,000 metric tons.

We are glad to make the correction accordingly.

Operations in a New Orleans Foundry*

By Frank A. Stanley

THE photographs herewith illustrate some of the operations of a New Orleans foundry engaged in the production of sugar machinery.

The greater part of the work of this firm is of a very heavy character and much of it is loam molding in which the cores and molds are swept up by striking boards or sweeps. The sweeps are made of rigid metal striking bars or spindles held vertically in heavy brackets with suitable bearings and carrying adjustable arms to which the boards are bolted for various sweeping operations. A view of such work is shown in Fig. 1. Most of these molds are made up of brick and loam with a certain amount of clay in spots. The sand or loam inside the brick mold is usually ¾ to 1 in. thick, and commonly loam is used as a binder for holding the bricks together. The building up of the mold by the sweeping process is followed by baking over night in big core ovens, the whole brick mold being picked up bodily by overhead cranes and transferred to cars which are run into the ovens.

In molding big rings, drums, cylinders and the like the brick and loam work is built up and swept to any desired height and diameter and both molds and cores are handled advantageously in this manner.

An Interesting Molding Job

A job of special interest is represented by Figs. 2 and 3. This is the molding of a cone-shaped casting which is part of a calandria vacuum pan. The casting is of brass and its diameter is 13 ft. or more, depending upon the size of vacuum pan manufactured. In the conical face of this casting there are cored over four hundred 3½-in. holes, which are afterward ma-

*Reprinted from *American Machinist*, vol. 53, p. 441; Sept. 2, 1920.

FIG. 2. PART OF A MOLD FOR A VACUUM PAN

chined to receive the ends of short copper tubes connecting two of these cone castings together in the assembled vacuum pan in much the same manner as tubes are placed in a boiler. The cone casting in the 12- or 13-ft. size is about 6 ft. high. The thickness of the metal in the wall is about ½ in.

The lower half of the mold, Fig. 2, is built up first,
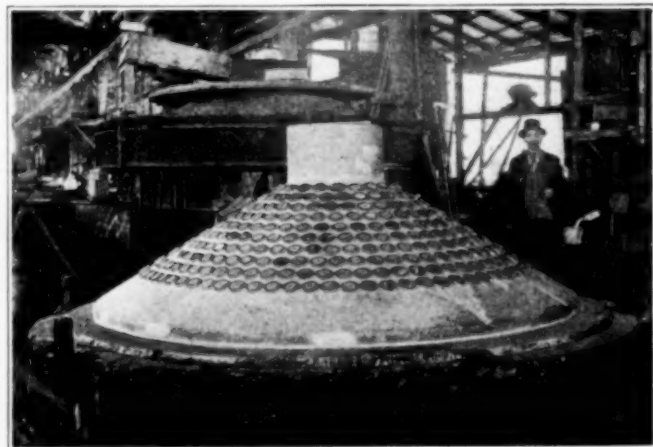
FIG. 3. OVER 400 CORES IN PLACE

loam and sand being used over a brick center and the cone swept to dimensions ready for baking in the oven. This cone is used as a core or center for the molding of the supper half of the mold, and for this purpose a half-inch thickness of sand is left all the way round on the lower cone to represent the thickness of metal to be run. The top half of the mold is placed in position and molded to the lower cone.

Afterward the half-inch of extra sand thickness is swept off the lower cone and the latter is scribed with a series of lines around its surface for the accurate placing of the 3½-in. cores to form the openings through the walls. These small cores are dry sand, baked as usual, and are positioned as shown by Fig. 3, where they may be seen in ten circles around the cone.

When the top of the mold is placed in position the metal is poured through the neck and flows down over the sloping cone. About 3,700 lb. of metal is run in this job. The operations illustrated are from the plant of Dibert, Bancroft & Ross, New Orleans, La.

Report on Helium Study Expected Soon

The field work in connection with the helium study being made under the general supervision of the Bureau of Mines will be completed within a month. A report on the work will be available shortly thereafter.

FIG. 1. THE SWEEP IN POSITION

A Disastrous Explosion of Aluminum Dust

A Description of the Investigation by Federal and State Officials of the Causes Leading to the Aluminum Dust Explosion, the Manner in Which the Explosion Occurred and the Results of This Investigation

BY DAVID J. PRICE*

IN RECENT years a large number of disastrous explosions have occurred in industrial plants in both the United States and Canada. Careful investigation of these explosions has shown that in many cases the ignition of flammable dusts created during the operating processes has resulted in large losses of life and extensive property damage. Some of these explosions have taken place in industries where "dust explosions" had not previously been known to occur and the necessity for control methods were not fully recognized. Among the more recent explosions of this nature was an explosion in an aluminum goods manufacturing company's plant in a Northwestern state, which attracted the attention of the engineers engaged in prevention work. The explosion caused the death of six girls and injuries to as many more.

A thorough investigation by Federal and state officials indicated that the explosion was due to the ignition of "aluminum dust" by sparks produced by the friction of a piece of wire on the interior parts of an exhaust fan. This article reviews in a brief manner the circumstances under which the explosion occurred and the results of this investigation.

PROCESSES ENGAGED IN

At the time of the explosion the company was engaged in the manufacture of a complete line of aluminum ware, such as teakettles, teapots, cooking utensils and similar articles manufactured from this material. The aluminum was delivered to the factory in sheet form, varying in size, gage and length, and ranging in width from 7 to 24 in. After the metal sheets entered the factory they were given a light coat-

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FIG. 1. EXTERIOR VIEW OF PLANT, SHOWING ARRANGEMENT OF BUILDINGS. EXPLOSION OCCURRED ON TOP FLOOR OF WING "C."

ing of grease to assist in the handling and to prevent tearing and cracking during the processes of cutting, punching, stamping and spinning. The grease and dirt were later removed by passing the articles, after shaping, through naphtha, lye or acid baths. They were then dried and ready for the finish application.

Four different finishes were applied, depending on the article. For convenience these finishes may be designated as (1) high polish, (2) satin, (3) acid and (4) emery. The explosion occurred in the satin-finishing department located on the third floor of Wing "C" (Fig. 1).

SATIN-FINISHING DEPARTMENT

The satin-finishing department was located in a room on the third floor approximately 200 ft. long and 40 ft. wide, occupying a little over one-third of the south end. About twenty-five girls were employed in this department. In addition about thirty other persons

FIG. 2. VIEW SHOWING DUST-COLLECTING PIPE, UNDERNEATH WORK BENCH, IN WHICH EXPLOSION OCCURRED

worked in the room in connection with other departments. The girls affected by the explosion worked in the satin-finishing section.

Nine lathes were used in this satin-finish process. These machines were placed on a long wooden bench, and two girls were employed to a machine. The lathes were made up of a spindle approximately 30 in. long with a circular steel brush at each end. This brush was made of fine steel wires, radiating from the center. The satin or "scratch" finish was applied by placing the aluminum ware against the revolving steel brush. During this process fine particles of the aluminum are removed. This creates what might be termed

"aluminum dust," and for sanitary reasons an exhaust system was installed to aid in its removal and improve working conditions for the employees in this room.

DUST-COLLECTING SYSTEM

The steel brushes used in applying the satin finish were surrounded by hoods connected by a 3-in. pipe to a main trunk line, which averaged 12 in. in diameter. It was connected to a 35-in. exhaust fan with a 16-in. opening, which drew the dust from the machine and discharged it to the atmosphere outside. The trunk line extended underneath the bench (Fig. 2) and varied in diameter from 6½ to 16 in. This was about 56 ft. in length and was fitted with four 6-in. hand holes for cleaning purposes. The fan was constructed of steel and had a steel casing. It

deg. below zero; maximum, 16 deg. above zero; relative humidity, 29.7 per cent.

The finishers, all of whom were girls, were seated at their benches, when like a bolt of lightning a blinding flash of fire enveloped them and in an instant their clothing was a mass of flames. Six of the girls died from their injuries, while as many more were seriously burned.

The room in which the explosion occurred was well lighted, having sixteen large windows on the west side and twelve on the east side. Each opening was 6 x 8 ft., thirty panes of glass to the opening.

About one-sixth of these panes were shattered, and a few of the steel window frames were slightly bulged. Both side walls, which were 16 in. thick, were bulged. The west wall was sprung about 3 in. at the ceiling,
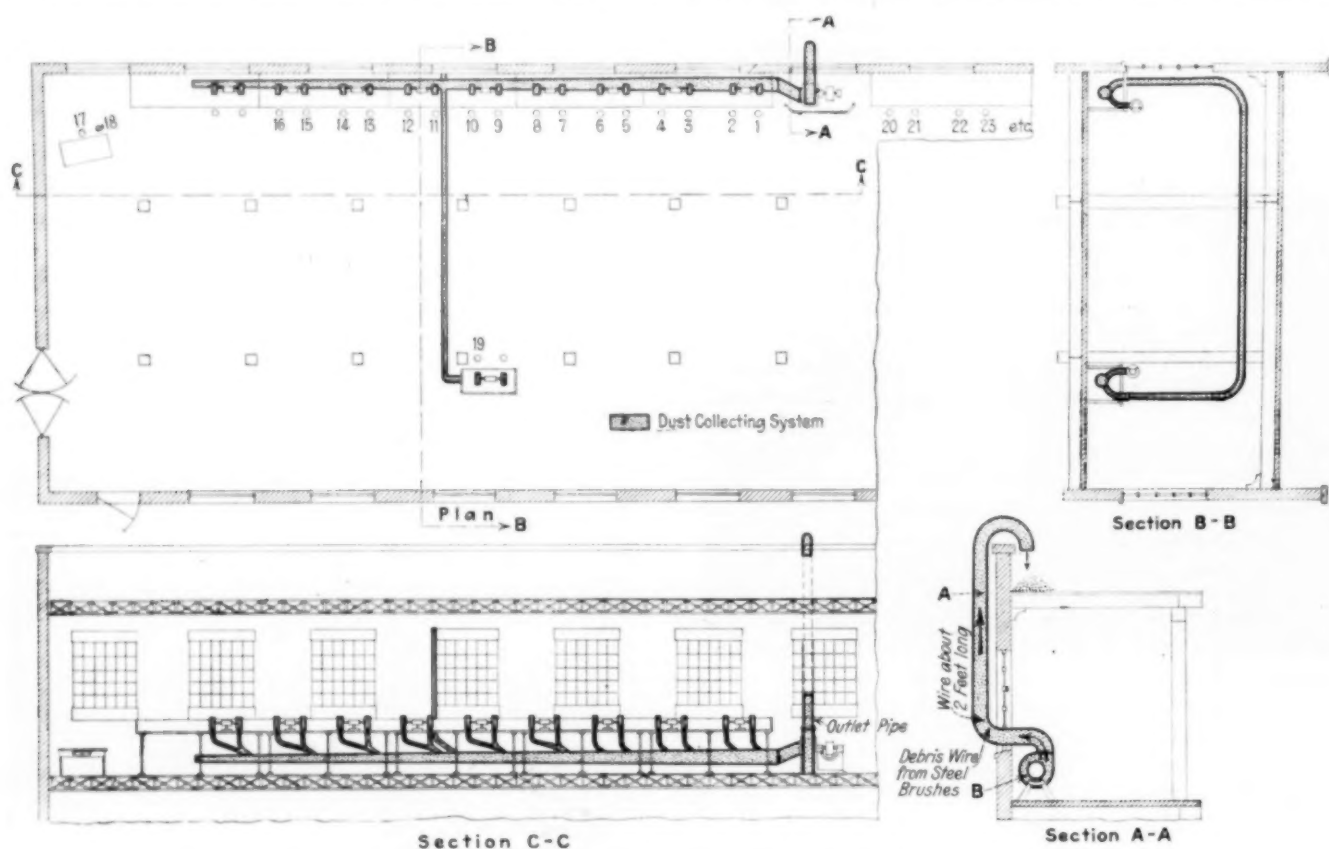
FIG. 3.   PLAN, ELEVATION AND SECTION OF OLD SATIN-FINISH DEPARTMENT, SHOWING THE DUST-COLLECTING SYSTEM

ran at 700 r.p.m., and discharged through a 12 x 12-in. opening.

The first three machine hoods were connected separately to the trunk line, while the remaining six machines were connected in pairs, one trunk leading from the main line and then separating one line to each hood (Fig. 3). The girls fatally injured were working at wheels 12, 13, 14, 15 and 16. The other injured employees were located at machines 1, 2, 10, 17, 18 and 19.

ACCOUNT OF EXPLOSION

The explosion occurred about 11 o'clock in the morning, Feb. 26, 1920, while the plant was in full operation with about 800 employees on duty. The explosion was accompanied by a loud report, which was heard for considerable distance from the plant. The weather was clear and cold with minimum temperature for day of 1

and the east wall was forced out about 2 in. at the same point. This crack appeared for a distance of about 50 ft. on each wall.

The damage to the building can be considered very slight, and no surrounding property was affected. The fire following the explosion was readily checked by the efficient sprinkler equipment within the building, combined with the excellent work on the part of the employees and officials, who fought the flames until the arrival of the city fire department. The general condition regarding upkeep and cleanliness of the plant was very good, a factor which must be recognized when the small area affected by the explosion is considered.

CAUSE OF THE EXPLOSION

The cause of the explosion was attributed to a piece of No. 7 B. & S. iron wire about 8 ft. long winding itself around the blades of the exhaust fan. The metal-

lic sparks as a result of friction of the wire on the interior parts of the fan ignited the finely divided aluminum dust. The fan was opened by C. W. Keniston, sanitary engineer of the State Industrial Commission, and the wire was found in position in the fan as shown in Fig. 4. A full view of the wire showing its length can be seen in Fig. 5.

How the wire was introduced into the fan was not definitely determined, but the general opinion prevailed that the wire entered the fan from the outside. The exhaust pipe from the fan extended out through a window and up to about 5 ft. above the roof level, and discharged onto the roof.

At the time of the explosion the company was engaged in erecting a new building adjacent, and various kinds of guy wires had been strung to the tops of near-by buildings. Whether through carelessness a piece of wire was laid on the mouth of the exhaust pipe or through malicious intent was placed within the pipe was undetermined at the time of the investigation.

The arrangement of the pipe leading from the fan to the roof was such that the wire coming in from

FIG. 4. VIEW SHOWING POSITION IN WHICH A PIECE OF NO. 7 B. & S. IRON WIRE WAS FOUND IN THE EXHAUST FAN

the outside would be required to pass through two 45-deg. turns. It is, therefore, possible that the wire may have been lodged in the pipe for some length of time, gradually working down by the vibration of the pipe until eventually it was struck by the paddles of the fan.

It was stated that two girls within 10 ft. of the fan, employed at a wrapping bench immediately north of the exhaust fan, heard a noise within the fan a short time prior to the explosion. This noise was heard distinctly on two occasions previous to the blast. It appeared to be simply a rattle, and one girl on hearing it arose from her chair and walked away from the fan. The explosion occurred before she could reach her sister, a distance of probably 8 ft. The second girl, who was sitting closer to the machine, heard the rattle three times and stated that the explosion occurred immediately following the third noise and that she saw smoke first before the blinding flash occurred.

Two pieces of wire were removed, one from the fan and the other from the exhaust pipe. This indicated that probably the original piece of wire was broken; one piece winding itself about the blades, and the other sticking in the pipe.

It appears that the trunk line under the bench was cleaned out at certain periods, approximately every two months. It was the intention to clean out this pipe a few days later. In removing the dust and dirt from the pipe a cable, along with a wooden scraper, was used. The wire found in the fan did not correspond to the description of the cable used in the cleaning process.
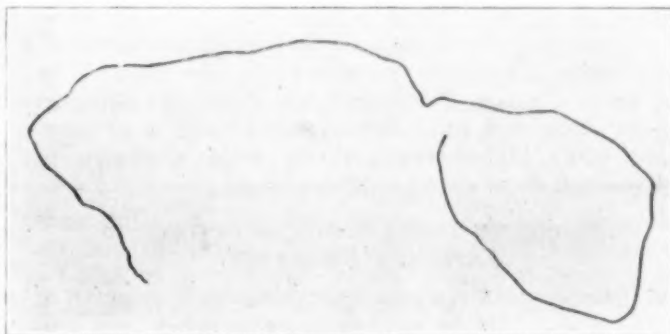
FIG. 5. FULL LENGTH OF WIRE FOUND IN THE EXHAUST FAN AFTER THE EXPLOSION

It was estimated that an average of about 30 lb. of dust and dirt was taken from the trunk line every two months.

PREVIOUS EXPLOSION

A slight explosion was observed in this exhaust system a few months previous to the disaster referred to in this article. A workman was engaged in cleaning out the exhaust system of the satin-finishing department prior to the time that the finishers came on for the day's shift. The fan was running, and during the cleaning process the wire being used came in contact with the fan blades. This produced a series of sparks, and an explosion followed which broke open the trunk line at the point it entered the fan. This definitely established the possibility of an ignition of the aluminum dust by sparks produced in this manner.

FLAMMABILITY OF ALUMINUM DUST

Samples of the aluminum dust were collected from the pipes of the suction system. In sifting the dust through cheesecloth of ordinary mesh onto the flame of a match, the dust readily ignited with brilliancy
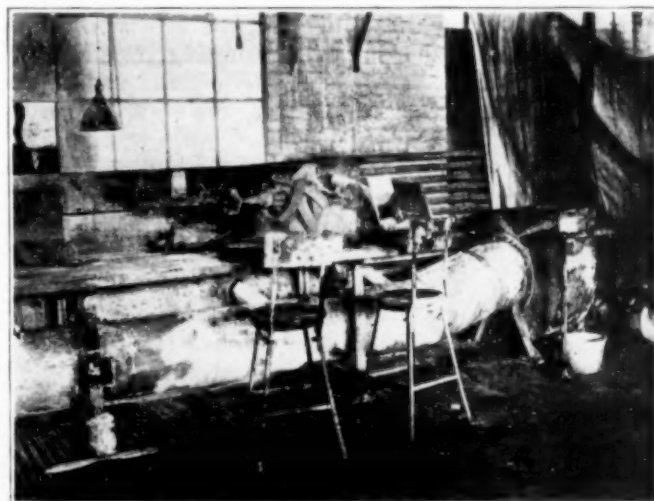
FIG. 6. VIEW SHOWING BRUSHES USED IN THE SATIN-FINISHING PROCESS AND CONNECTIONS LEADING INTO THE MAIN TRUNK LINE. NOTE THE COVER HOOD ON THE BENCH

and rapid propagation of flame. The Bureau of Mines, U. S. Department of the Interior, reports that "aluminum dust burns quietly when in a pile, but if this pile be disturbed in such a manner as to raise a cloud of dust into the air the burning takes place with explosive violence. If a dust cloud already formed that has a density within the explosive limits be ignited a violent explosion results." In experiments conducted in that bureau it was found that in some cases aluminum dust could be ignited at temperatures even lower than those necessary for the ignition of 200-mesh standard Pittsburgh coal dust. At 800 deg. C. the aluminum dust cloud ignited with a brilliant flash, while higher temperatures were necessary to ignite coal dust.[1]

RELATION OF DUST-COLLECTING SYSTEMS TO EXPLOSION FREQUENCY

A number of disastrous dust explosions originating in the dust-collecting systems have occurred in manufacturing plants in recent years. In an explosion of

PROPOSED NEW SYSTEM

The proposed new system, plans of which are shown in Fig. 7, is based on the fact that the aluminum and iron dusts, when in a finely divided state and mixed with air in proper proportions, form an explosive mixture, which can be ignited by an external source of heat or flame. The system was designed under the direction of C. W. Keniston, engineer in charge of industrial hygiene of the Industrial Commission of Wisconsin, and the following description is taken from his report to the commission:

1. The new system proposes to furnish a positive inlet for all air exhausted from the building, this to be provided for by an efficient ventilation system.

2. No exhaust ducts to be used. (Induced or secondary currents of air required.)

3. No exhauster used or no machine (through which air currents containing explosive mixtures are carried) in which moving parts are made of materials which could generate sparks.

FIG. 7. PLAN, ELEVATION AND SECTIONS OF NEW SATIN-FINISHING DEPARTMENT, SHOWING THE PRIMARY AND SECONDARY AIR DUCTS

chocolate dust in an Eastern plant, the explosion originated within the exhaust fan, presumably from sparks struck by foreign materials. The entire plant was destroyed, three lives were lost and the total property loss was estimated at $1,000,000. An explosion of flour dust occurred in a Western mill a few months ago in the trunking leading from the grinding rolls to the exhaust fan. Under the method of installation in these systems, as a rule, the dust and air are so well diffused in the pipes leading to the fan as to permit an explosive mixture to be present. When an ignition source of sufficient temperature is introduced, the dust cloud is readily ignited and the explosion propagates. The relation of dust-collecting systems of this nature to dust explosions and fire frequency has made evident the necessity for research engineering investigations to develop effective methods of prevention.

4. By the elimination of exhauster and exhaust ducts this system eliminates the contributing conditions to the explosion hazards and also the opportunity for the direct cause of the explosion to ever occur.

Tests and research work demonstrating the feasibility and practicability of the proposed system were made. The ducts for primary and secondary air are shown in Fig. 7. It will be noted that these secondary air currents, which pick up and carry out the aluminum dusts, pass through no equipment which could be an explosion chamber. Further details can be obtained through the Industrial Commission.

A certificate of inspection was issued to the company reading as follows:

There are required in your places of employment ventilation systems so designed, constructed and operated that the conditions of employment can be considered safe for health by the Industrial Commission.

Plans and specifications are to be submitted within a reasonable period of time. These plans must show the items on the following list which govern the design of your systems:

[1]Technical Paper 152, "The Inflammability of Aluminum Dust," by Alan Leighton, Bureau of Mines.

PLANS AND SPECIFICATIONS FOR VENTILATING AND EXHAUST SYSTEMS

List of factors which govern the design, and those details which govern the proposed installations should appear on the plans:

General surroundings.

Plans and elevations—with section if necessary.

Location of windows, roofs, partitions, exits.

Location of equipment and character of the work performed.

Number of persons employed and their distribution.

Available cubic feet of air space (total space less that taken up by equipment and materials).

Location of proposed ventilation and exhaust machinery.

Location and sizes of air inlets and outlets.

Location, size and shape of ducts and pipes.

Location, size and type of fans and motive power or ventilator.

Materials used in construction of fans and ducts.

Cubic feet of air moved per hour.

Velocity of air per minute produced at the throat of the hoods of exhaust systems.

Any proposed heating, cooling or purification apparatus used in connection with the system.

Any apparatus used to take care of the discharge of the system.

After the above-mentioned research had been carried on to the satisfaction of the Industrial Commission, the following recommendations and requirements were added to the above-mentioned certificate of inspection:

The following recommendation applies to the new plant, fourth floor. We recommend that the system required as a protection to health in the satin-finishing department be designed, constructed and operated in the following-described way so that the conditions of employment can be considered safe for health in all ways, including explosion hazards:

Static suction required in the hoods must be produced as an induced current of air by the use of a pressure air jet. This can be constructed in accordance with the experimental data found to be practical in a series of experiments conducted especially for this particular problem. The air currents carrying the dust must be carried to the outside atmosphere through the shortest pipe possible and without passing through any fans or large conveying ducts similar to those used in other exhaust systems. The air jets must be so constructed that the operator of each wheel may control the air jet used for its suction.

IMPORTANCE OF DUST EXPLOSION PREVENTION TO INDUSTRIES

The extensive losses to life and property as a result of the large number of dust explosions occurring in manufacturing establishments fully emphasizes the need for a thorough engineering study of the problem. Large quantities of foodstuffs are destroyed in these explosions and fires in the industries where food products are manufactured. In a period of less than 12 months —May, 1919, to April, 1920—at least six disastrous explosions, causing a loss of eighty lives and property damage to the extent of $7,000,000 have occurred. In addition a large number of explosions have taken place in factories, without any life loss or extensive damage.

In a "starch dust" explosion in a factory in the Middle West during the past year forty-three lives were lost and $3,000,000 property damage was done. In two explosions of grain dust, in modern elevators constructed of fire-resistive materials, one in the United States and the other in Canada, twenty-four lives were lost and as many others injured, with both plants badly damaged. In fighting a fire in a spice plant a few months ago, eighteen firemen were caught when a wall was "blown out" during the progress of the fire. Four of the firemen lost their lives and a thorough investigation suggested the possibility of the falling timbers forcing a cloud of "spice dust" onto the flames of the fire, causing an explosion.[2] Explosions are occurring in sugar refineries, starch factories, flour mills, grain elevators, chocolate plants and other similar industries where flammable dusts are created.

ENGINEERING INVESTIGATIONAL WORK

The Bureau of Chemistry of the U. S. Department of Agriculture, in co-operation with the milling and grain companies throughout the country, is conducting investigational research work to develop methods for the control and prevention of dust explosions in industries where grain or its products are handled. In order to assist the bureau in this work and to obtain all information available pertaining to the behavior of these explosions, the disaster in the aluminum plant was carefully studied by the engineers. This procedure has also been followed in the investigation of dust explosions in other types of industrial plants.

The results of the investigation after the explosions in not only the grain-handling plants but in the other manufacturing establishments as well have developed many essential lines of engineering work. The explosions are not only occurring in many cases in industries where they had not been experienced previously but the investigations are developing new causes relating closely to construction of plant, mechanical operating equipment, dust-collecting and control methods and similar factors. The explosions have taken place in some of the largest manufacturing plants in the United States and Canada, where the safety engineers were applying all known preventive measures. Before dust explosions of this nature can be effectively controlled, these new problems arising must be solved, in order to reduce our losses to life, food and property.

A Method for Determining the Opacity of Eye-Protective Glasses to Ultra-Violet Rays

A quick method for determining the opacity of eye-protective glasses to ultra-violet rays has been worked out by the U. S. Bureau of Standards. The photographic method usually employed requires several hours for making such a test, while by the new method, which is radiometric, a test can be made in a few minutes. The test is based upon the fact that all glasses are opaque to radiations of wave lengths less than 0.3 micron (1 micron = 1/1,000 mm.). It is, therefore, only necessary to examine eye-protective glasses for opacity to ultra-violet radiations of wave lengths 0.3 to 0.4 micron. Radiations of these wave lengths are easily obtained without employing a spectroscope by simply filtering the light from a quartz vapor lamp through a suitable glass screen placed over a vacuum thermopile. Measurements of one part in 10,000 are easily obtainable, whereas on the basis of the requirements of the proposed Safety Code for Head and Eye Protection, an accuracy of one part in 1,000 is all that is necessary.

Rice Straw as Raw Material in the Paper Industry

According to *Eastern Engineering*, a combine of Dutch paper manufacturers proposes to establish a factory in the Dutch East Indies for the manufacture of paper from rice straw. It is stated that excellent writing paper has already been made from this material.

[2]"Will Spice Dust Explode?" *Simmons Spice Mill*, August, 1920, and *Tea and Coffee Trade Journal*, August, 1920.

Legal Notes

By Wellington Gustin

Oral Agreements Excluded When Written Contract Is Neither Uncertain Nor Ambiguous

Judgment for the Detroit Copper & Brass Rolling Mills has been affirmed by the United States Circuit Court of Appeals, Eighth Circuit, in the action brought against it by the Century Electric Co., of St. Louis. The controversy arose out of a written contract of sale of 400,000 lb. of brass rods, a portion of which were returned by the Century company because it was claimed they were too hard to be cut and made into brass primers by automatic screw machines.

The Detroit company defended on the ground that it was under no obligation to make the rods of such a degree of hardness that they could be so machined. The written agreement contained no covenant of that nature.

The Century company offered to prove that in the negotiations for the contract, just before it was made, the Detroit company made an oral agreement to that effect. The court ruled out this evidence because it varied a written contract, by adding a new covenant to it. The Century company contended that there was an implied warranty to that effect, but the trial court held otherwise, and directed a verdict for the Detroit company. An appeal was had on these disputed grounds.

In the written contract the ingredients of the brass rods are stated in these words: "The basis for the mixture to consist of 60 parts copper and 40 parts spelter." Other provisions of this contract covered the amount of the rods, times, place and manner of delivery, prices and payments. The contract ends with the statement that the written agreement is the final understanding of the parties and no changes may be made unless reduced to writing and signed by both parties.

This sale was solicited by the Century company, the purchaser, which had a contract with the Bethlehem Steel Co. to furnish Russian brass primers for 3-in. shells. The Century company asked for quotations on the brass rods described in the contract, and the Detroit company gave prices, followed by a personal interview of four hours between the agents of the corporations and the execution of the contract upon the close of that conference.

Written Contract Conclusive, Decides Court

The Century company offered to sustain its claim that the Rolling Mills made an oral agreement and an implied contract to sell it brass rods soft enough to be readily cut and made into brass primers by the use of automatic screw machines. In its opinion the Court of Appeals pointed out that the written contract clearly describes the ingredients of the mixture. When the parties were negotiating for the contract, the buyer might have required, and if the seller had consented, might have obtained a provision in the written agreement that the seller would sell and deliver brass that could be readily cut and made into Russian primers by the use of automatic screw machines, but it did not do so, said the court. When the parties selected, out of the numerous suggestions discussed during their four-hour conference, the terms to which they agreed and which

they embodied in their written contract, the legal presumption arose that they had rejected and did not agree to or intend to agree to the suggestions discussed in the negotiations which were omitted from the writing. And where, as in this case, the written contract imports a complete legal obligation free from uncertainty and ambiguity, that presumption is conclusive, said the court.

It further said the rule that all previous negotiations are merged in the written agreement, and that parol evidence to modify it is incompetent, rests upon the conclusive presumption that the parties have written into it every material term and item of their agreement, and evidence of a contemporaneous parol contract is as incompetent to add another covenant or term to the writing as it is to change a covenant or to withdraw it therefrom.

However, the buyer contended that the seller knew the custom of cutting and making the rods into Russian primers by the use of automatic screw machines, that the seller represented that he could produce the goods to make such primers, that it had sold brass rods for this purpose to another concern, which had bought brass rods from another brass company, which were defective, and had finally come to it to get the proper kind of brass, and therefore there arose an implied warranty that the brass it sold the Century company would be of such proper hardness.

All Agreements Should Be in the Contract

Answering this contention, the court said that if the buyer had employed the seller to make and deliver brass rods to be cut and made into Russian primers by automatic screw machines, and had intrusted to the judgment and skill of the seller the ingredients and composition of the mixture from which the rods should be made and the percentage of lead which the rods should contain, such a warranty might have arisen.

It might have specified and written into the contract the exact proportion of lead the bars should contain, so that they could be readily machined, for the proportion of lead in the rods conditioned their hardness. It might have written into that contract that the seller should use such a proportion of lead as would make them readily machinable. It did neither of these things, but expressly provided in the writing that the mixture should contain 40 parts spelter and 60 parts copper, and then, three days after the making of the contract, telegraphed the seller that the rods must contain only 1 per cent of lead, which latter terms were accepted by the maker.

Therefore, the seller made and delivered a product which complied with all these requirements of the contract and the rule applies that, when a known, described and definite product is ordered of a manufacturer, although it be stated by the purchaser to be required for a particular use, yet if the known, described and definite thing be actually supplied, there is no implied warranty that it shall answer the particular purpose intended by the buyer (cf. 79 Fed., 43 and 611).

Again, the terms of the written contract show that the express warranty of the contents of the mixture and of the proportion of the lead in it, which conditioned the degree of its hardness, raises the conclusive presumption that no other warranty of their degree of hardness was implied. The express warranty of one or more of the qualities of an article excludes an implied warranty of the same qualities or of other qualities of a similar nature.

Steel Rails From Sink-Head and Ordinary Rail Ingots—I

General Plan of Investigation—Ingot Practice—Temperature Observation—General Comparison of Two Ingot Types—Comparison of Chemical Composition —Items Relating to Manufacture

BY GEORGE K. BURGESS*

THE results of the experimental rolling into rails of several types of ingot, including several designs of sink-head ingot and others, with the co-operation of the Maryland Steel Co., reported by Messrs. Hadfield and Burgess[1], looked sufficiently promising to the rail committee of the Pennsylvania Railroad to warrant the purchase of 100 tons of ingots cast by Sir Robert Hadfield in England, in order to make a more effective study of the suitability of this type of sink-head ingot for the manufacture of rails. It was also considered desirable to carry out similar series of tests of ingots of ordinary rail steel rolled at the same time and under as nearly identical conditions as possible in the same mill[2]. President F. W. Wood of the Maryland Steel Co., Sparrows Point, Md., offered the facilities of that plant for this investigation, as in the case of previous experiments reported by Hadfield and Burgess. The rolling of ingots for the present investigation was done in 1915 at the Sparrows Point plant, then known as the Maryland Steel Co., now a part of the Bethlehem Steel Co.

The planning of the details of the investigation, after correspondence with Sir Robert Hadfield, was made by A. W. Gibbs, chief mechanical engineer of Pennsylvania Railroad Co.; F. W. Wood, president of Maryland Steel Co., and the present writer, and the tests were carried out by members of the technical staffs of their representative organizations, to whom acknowledgment is here made for their indispensable aid.

It was expected by Sir Robert Hadfield that the sink-head ingots made under this system[3] would yield rails of remarkably high quality as regards "soundness, freedom from all piping and all segregation." From an inspection of the data concerning the manufacture of the ingots made by this process he also felt confident

in stating: "This shows in a remarkable manner the uniformity of the ingots, also that every one of them is perfectly sound, free from blowholes. with no piping and segregation below 8 per cent discard."

The results of the present investigation of thirty-seven ingots of the Hadfield type (Fig. 1) show that he was not far astray in the confident prediction of uniformity, physical soundness, and freedom from chemical segregation. In fact, it is difficult to imagine thirty-seven ingots from as many different heats of bessemer steel more uniform in quality and properties and as free from those undesirable qualities and uncertainties that beset the ordinary ingot.

The ingots with which they were compared, the prod-
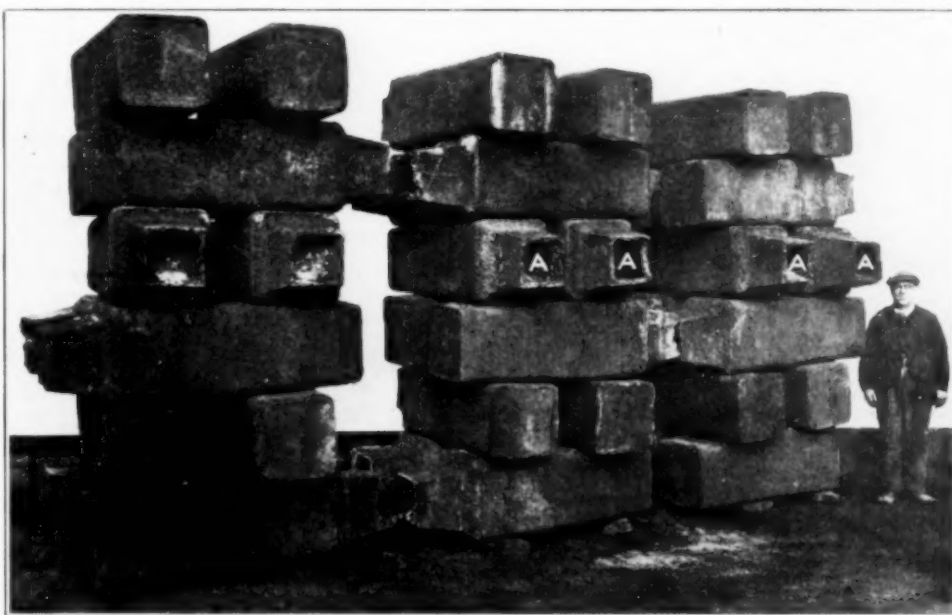
FIG. 1.   ONE HUNDRED TONS OF HADFIELD INGOTS SUPPLIED TO THE PENNSYLVANIA RAILWAY

uct of three heats, five from each heat, or fifteen ingots in all, are not less instructive, in that each group, or heat, represents a distinct practice in open-hearth manufacture. In this investigation, therefore, from the point of view of steel-making, we are really comparing the products rolled from two types of ingot representing four methods of manufacture.

The rolling, inspection, tests and analyses were car-

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ried out with the greatest care, and by a series of actual weighings all the material from the several ingots was accounted for.

INGOT PRACTICE

Since the sink-head ingots were cast in England and rolled in this country they were necessarily subjected to the unusual process, at least in rail manufacture as ordinarily practiced, of reheating from the cold condition. The plan was considered of allowing at least some of the comparison ingots to go "stone cold" and reheat them before rolling. However, in view of the fact that the ordinary type of ingot is not designed to meet this condition, which practically never obtains in practice and which therefore would be a possible misleading condition to impose on the comparison ingots and of no practical value, the Maryland ingots were all rolled directly after being cast. These ingots were stripped from 20 to 30 min. after casting and put while still hot into the soaking pits, where they remained from 1 hr. 40 min. to 2 hr. 23 min.

The sink-head ingots after preliminary heating were charged into relatively cool pits. The heat was gradually turned on after ½ hr. and the ingots remained in the pits from 17½ hr. to 21½ hr. The thirty-five sink-head ingots which were rolled were divided into three series and rolled on successive days, Aug. 16, 17 and 18, 1915. Three heats of comparison ingots were rolled, one on Aug. 16 and two on Aug. 18. There was no delay or other unusual condition in the mill during the rolling. The ingots of a group were rolled in succession, without intermission, and after the mill had been warmed up by rolling at least one complete heat of the regular product of the mill.

TEMPERATURE OBSERVATIONS

Temperature observations were taken of the soaking pits before, and at intervals after, immersion of ingots

Ingot No.	Temp. of Soaking Pits at Time of Charging Ingots Deg. C	After 14½ Hours Deg. C.	Ingot Temperature		1st Rail Bar Deg. C.	2nd Rail Bar Deg. C
			When Drawn Deg. C.	Blooming Mill Deg. C.		
1	700	1310	1300	1130	1016	1007
2	700	1310	1300	1140	1030	1020
15	700	1310	1300	1137	1026	1017
21	700	1310	1300	1123	1025	1005
24	700	1310	1300	1172	1025	1010
28	700	1310	1300	1157	1019	1008
7	750	1300	1290	1125	1028	998
9	750	1300	1290	1149	1024	1016
13	750	1300	1290	1116	1034	1008
14	750	1300	1290	1143	1043	1019
22	750	1300	1290	1144	1032	1018
35	750	1300	1290	1140	1034	1011
6	650	1200	1295	1149	1048	1025
18	650	1200	1295	1166	1032	1023
19	650	1200	1295	1180	1069	1044
23	650	1200	1295	1154	1047	1026
26	650	1200	1295	1173	1047	1034
31	650	1200	1295	1146	1036	1016
4	650	1240	1280	1156	1040	1016
10	650	1240	1280	1147	1046	1022
11	650	1240	1280	1138	1029	1012
12	650	1240	1280	1142	1047	1029
29	650	1240	1280	1148	1034	1005
36	650	1240	1280	1136	1038	1016
16	600	1305	1315	1182	1018	955
17	600	1305	1315	1164	1036	1016
20	600	1305	1315	1179	1045	1023
27	600	1305	1315	1153	1040	1024
30	600	1305	1315	1157	1032	1020
33	600	1305	1315	1160	1029	1017
3	600	1300	1316	1156	1033	1023
5	600	1300	1316	1149		
8	600	1300	1316	1151	1029	1023
25	600	1300	1316	1153	1035	1000
34	600	1300	1316	1140	1014	1004
Average	658	1276	1299	1150	1034	1014
Maximum	750	1310	1315	1182	1069	1044
Minimum	600	1200	1280	1116	1014	955

Sinkhead Ingot Nos.				Comparison Ingot Nos.			
7	14	28	34	2	7	13	15
1,136	1,152	1,181	1,165	1,184	1,179	1,179	1,168
1,147	1,147	1,171	1,165	1,171	1,179	1,171	1,157
1,144	1,136	1,162	1,157	1,168	1,176	1,168	1,136
1,114	1,147	1,147	1,141	1,184	1,160	1,157	1,149
1,123	1,141	1,147	1,131	1,171	1,163	1,157	1,147
1,125	1,141	1,147	1,123	1,165	1,157	1,147	1,136
1,112	1,139	1,147	1,120	1,163	1,157	1,147	1,144
1,103	...	...	1,125	...	...	...	...
Av. 1,125	1,143	1,157	1,141	1,173	1,167	1,161	1,149

Grand average............... 1,145   Grand average 1,168
Maximum................... 1,213   Maximum... 1,206
Minimum.................. 1,093   Minimum 1,136

TABLE III. TEMPERATURES OF WORKING OF COMPARISON INGOTS

Ingots		Rails	
Ingot No.	Blooming Mill, Deg. C.	At Finishing Pass (Taken on Base of Rail)	
		1st Rail Bar, Deg. C.	2nd Rail Bar Deg. C.
1	1,149	1,026	1,006
2	1,173	1,016	993
3	1,164	1,040	1,025
4	1,179	1,053	1,039
5	1,177	1,064	1,027
6	...	1,031	1,005
7	1,167	1,029	1,018
8	1,176	1,030	1,001
9	1,159	1,038	1,009
10	1,180	1,038	...
11	1,162	1,039	1,003
12	1,181	1,046	1,025
13	1,161	1,032	1,018
14	1,149	1,025	1,016
15	1,149	1,024	1,018
Average	1,166	1,035	1,001
Maximum	1,181	1,064	1,039
Minimum	1,149	1,016	993

of both types; of all ingots in the blooming mill; and of rails from both series of ingots at the finishing pass. In order to heat them gradually, the Hadfield ingots lay on the surface of the soaking pits approximately 12 hr. before charging. They were too hot to bear the hand comfortably when charged, at which time their estimated temperature was about 50 deg. C. (122 deg. F.). The pits which received these sink-head ingots were allowed to cool to the temperature of 600 deg. C. (1,112 deg. F.) to 750 deg. C. (1,382 deg. F.). (Table I.) The immersion of the ingots further cooled the pits by about 200 deg. C. (392 deg. F.) as measured immediately after charging. The gas was turned on the pits ½ hr. after charging. The Maryland ingots were charged into the soaking pits hot according to the usual practice.

The temperatures of Table I were taken with a platinum-rhodium thermocouple connected to a pivot type of indicator. The couple was enclosed in nickel sheath except the tip, which was exposed. In some cases the temperatures were obtained by the use of an optical pyrometer of the Morse type.

By means of the optical pyrometer, temperatures of the ingots were taken during rolling. Average values, obtained from seven or eight observations with optical pyrometer at alternate passes, after the first roughing pass, were taken of the ingots in the blooming mill. The temperature of the steel at the surface was lowered about 17 deg. C. (63 deg. F.) to 40 deg. C. (104 deg. F.) during the rolling into blooms. Typical illustrations of rolling temperatures are given in Table II for several ingots of both types. Table I contains finishing temperatures of Hadfield rail bars, taken at the finishing pass, by sighting on the center of base of rail bar with an optical pyrometer. Each observation is the average of two readings.

In Table III are similar data for the comparison ingots and rails, except that the pit temperatures were not taken. It will be noted that good uniformity of rolling and finishing temperatures was obtained.

A series of measurements was taken to compare the temperatures of this investigation taken at the finishing pass with those taken' at the hot saw by sighting on the head of the rail. The reading noted in Tables I and III of finishing temperatures should be reduced by about 11 deg. C. (52 deg. F.) to correspond to previous observations at hot saw.

The observed ingot and rail temperatures were taken on the outside oxidized surfaces, which are colder than the interior metal by 75 deg. C. (167 deg. F.) to 100 deg. C. (212 deg. F.). This would account for the apparent discrepancy between the soaking-pit and ingot temperatures, and would make the average true finishing temperature somewhat higher than 1,100 deg. C. (2,012 deg. F.).

General Comparison of the Two Ingot Types

Method of Numbering Ingots. The sink-head ingots were numbered H1, H2, etc. . . . H37, and the ingots made in the ordinary manner were numbered M1, M2, etc. . . . M15.

Weight of Ingots. The sink-head ingots were weighed cold and the others were weighed hot. The approximate weight of the sink-head ingots was 5,300 lb. each, and of the Maryland ingots 7,300 lb.

Size and Shape of Ingots. The English-made ingots were cast with sink-head on large end, while the American-made ingots were cast small end up. Hadfield's ingots were 19½ in. square on top, 17¼ in. square at the bottom and 50½ in. high, exclusive of 13¾ in., the approximate height of the sink head. American ingots were 18¼ in. square on top, 19¼ in. square on bottom and

'Bureau of Standards Tech. Paper 38, "Observations on Finishing Temperatures and Properties of Rails."

63 in. high. Further details of the sink-head cavities may be had from Table IV.

Loss in Heating. The sink-head ingots were weighed while cold before reheating and the comparison ingots were weighed while hot. The abnormal loss in weight sustained by the former should be deducted from the nominal ingot weight in computing the net ingot. It so happens that the average bottom bloom crop for the ingot made in an ordinary manner is 0.5 per cent greater than for the sink-head ingot; so that if the loss on heating for the comparison ingots is taken as 0.5 per cent there will be an exact balance. The English cast ingots remained in the soaking pits about ten times as long as the comparison ingots. If it is, nevertheless, preferred to compare actual percentages of material available for rails, that from the sink-head ingots should be increased by 2.5 per cent, since there was a loss of 3 per cent, of which about 2.5 per cent can be charged to reheating. When this correction is made, it will later be shown that the average sink-head ingot gives about 84.8 per cent material available for rails instead of 81.9 per cent. (Ingot H24 should not be used in the computation, as it was accidentally given an excessive bloom crop.) The expression "material available for rails" as here used refers to physically sound steel only. Subsequent chemical analyses showed a much greater discard was necessary to eliminate segregation above 12 per cent, as will be shown later in Tables XII and XIII.

Comparison by Heats. It will be noted that the three heats of comparison ingots have each very distinct characteristics, as expressed, for example, in material available for rails, which are the results of varying open-hearth and casting practice. In group M1 to M5, the percentage of material available for rails was 86.9 per cent; in group M6 to M9 85 per cent, and in group M11 to M15, 65.8 per cent (Table VI). It was for this reason that, in addition to the general average of prop-

TABLE IV. CHEMICAL COMPOSITION AND HEAD PARTICULARS OF SINK-HEAD INGOTS, REPORTED BY SIR ROBERT HADFIELD

Ingot No.	Heat No.	Chemical Composition					Sink-head Particulars			
		Per Cent					Height to Which Filled in Head, In.	Depth of Settling, In.	Capacity of Cavity, c.c.	Percentage of Settling to Total Bulk of Ingot
		C	Si	S	P	Mn				
H1	4774	0 65		0.040		0 94	14 00	8.25	9,950	3.19
H2	4738	0 63-0.64		0.042		0.91	13.50	9.00	10,300	3.31
H3	4847	0 63-0.64		0.047		0.93	13.75	9.25	10,450	3.37
H4	4915	0.65-0.66		0.049		0 92	14.00	9.75	9,675	3.10
H5	4873	0.69		0.050		0 95	14.00	9.38	10,250	3.29
H6	4939	0 63-0.64	0.16	0.045	0.028	0.92	13.00	7.50	8,800	2.84
H7	4627	0.64		0.052		0.97	14.00	8.25	9,600	3.08
H8	4680	0.65	0 14	0.049	0.029	0.92	13.75	8.50	10,250	3.29
H9	4709	0.58		0.049		0.93	13.00	7.75	8,930	2.88
H10	5085	0 63-0.64	0.16	0.042	0.031	0.86	13.25	9.25	11,000	3.52
H11	5018	0.64	0.16	0.039	0.031	0.92	14.00	8.75	10,040	3.21
H12	4641	0.67-0.69		0.045		0 92 0 94	14.50	8.50	9,000	2.89
H13	5059	0 63-0.64		0.049		0 92	14.00	8 88	10,750	3.44
H14	4835	0.69		0.046		0 91	13.50	7.75	9,520	3.05
H15	4978	0 67-0.68		0.051		0 96	14.50	9 88	9,260	2.95
H16	4992	0 66		0.045		0 94	13.50	9.75	9,000	2.88
H17	4825	0.66		0.045		0 92	13.50	6 88	9,000	2.89
H18	4829	0.66		0.041		0.98	14.00	8.50	11,100	3.55
H19	5073	0 63-0.64		0.045		0 90	14.00	9 50	10,500	3.37
H20	4696	0 66		0.038		0 96	13.50	6.50	8,600	2.77
H21	4801	0.66		0.036		0 95	13.50	8 13	9,150	2 90
H22	4723	0.63		0.044		0 95	13.50	8 00	9,900	3 17
H23	5046	0 62-0.63		0.042		0 93	13.50	7 00	10,500	3.37
H24	5030	0.60		0.056		0.94	13.50	10 13	11,950	3.82
H25	4668	0 58		0.042		0 93	14.50	8 50	10,100	3.24
H26	4813	0.64	0 14	0.048	0 032	0 93	14.00	8 63	10,800	3.45
H27	4615	0.64	0.20	0.048		1 01	14.25	7 00	9,000	2 89
H28	4588	0.64	0.19	0.047		0 97	13.00	7 25	8,930	2 86
H29	4908	0.64		0.041		0 84	14.00	8.75	9,750	3 11
H30	4851	0.61-0.62	0.21	0.045	0 031	0 92	14.00	9 63	10,900	3 49
H31	4600	0.65	0.15	0.049		0 96	13.50	8 50	9,825	3 16
H32	5004	0.65		0.052		0.94	14.00	8 50	10,175	3 27
H33	4761	0.65		0.048		0 90	13.50	8 50	10,800	3 47
H34	5099	0.63-0.64		0.039		0 86	11.00	8 88	10,040	3 34
H35	4887	0.63		0.050		0 89	14.00	9 00	10,500	3 36
H36	4653	0.61		0.053		0 85	13.50	7.75	9,900	3 17

erties of all Maryland rails, averages were computed for each of the three Maryland heats. The three rollings of the Hadfield ingots show great uniformity, however expressed, and this indicates that the manufacture of the ingots in all cases apparently was carried out in accordance with a uniform practice.

Inspection of Ingots. The sink-head ingots were examined while cold for surface defects, and the surface condition of all ingots was noted by another observer as they passed through the blooming mill. There were side splashes, rough sides and rough corners on nearly all the sink-head ingots, and only four of the thirty-five were noted as clean blooms in rolling, as compared with eight clean blooms from the fifteen comparison ingots.

COMPARISON OF CHEMICAL COMPOSITION

Sink-Head Ingots. The chemical composition of the sink-head ingots (Table IV) and the rails therefrom shows a remarkable degree of uniformity. Thus, for the

per cent, with a deviation of 0.004. For the top of the web the concordance is somewhat less good. Manganese and silicon are very uniformly distributed.

Comparison Ingots. These ingots were cast with small end uppermost of analysis shown in Table V and

TABLE V. COMPOSITION OF MARYLAND STEEL

Heat No.	2x4497	1x3632	2x4510
Ingot Nos.	M1 to M5, incl.	M6 to M10, incl.	M11 to M15, incl.
Per cent carbon	0.608 to 0.630	0.642 to 0.654	0.642 to 0.650
Per cent silicon	0.148	0.185	0.191
Per cent sulphur	0.067	0.092	0.097
Per cent phosphorus	0.010	0.014	0.019
Per cent manganese	0.710 to 0.720	0.650 to 0.660	0.760 to 0.810
Per cent chromium	0.270	0.290	0.270
Per cent nickel	0.760	0.780	0.760

except for a nickel content of 0.75 per cent and chromium content of 0.28 per cent accompanying the Cuban ore used in the blast furnace, they were of a composition and uniformity comparable with the sink-head type, the average "O" (tread) position having a car-

Sink Head Rollings

Comparison Rollings
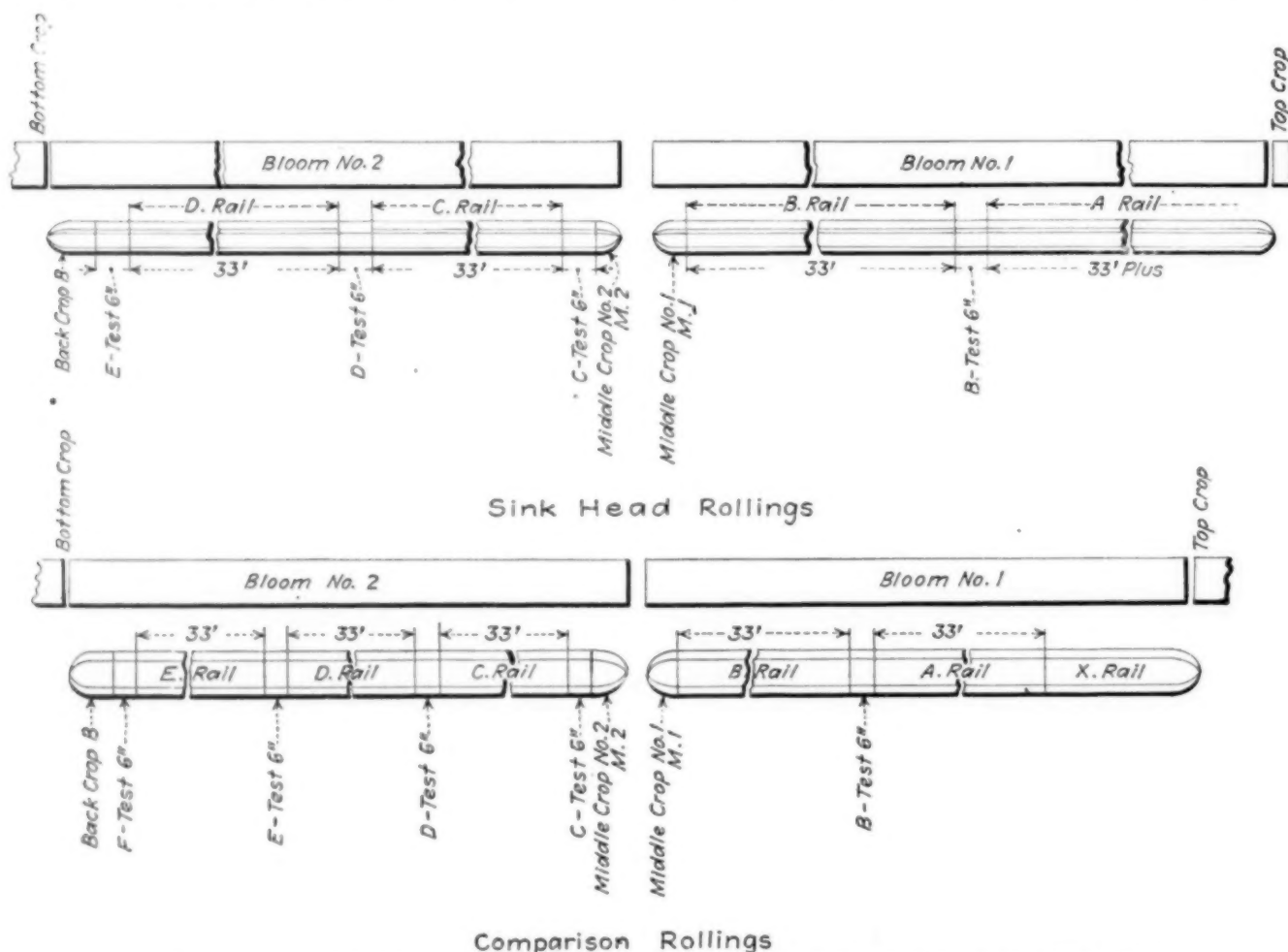
FIG. 2. DIAGRAM SHOWING CUTTING OF BLOOMS AND RAILS FROM INGOTS OF BOTH TYPES

"O" analysis (near the tread) the average carbon is 0.648 per cent, with an average deviation from mean of 0.017. If we take the "C" test piece (top crop from the second bloom) as representing the ingot composition, the average for carbon at the top of the web is 0.644 per cent and near the tread is 0.653 per cent, the average deviation from mean in each case being 0.017.

The average phosphorus content of the tread position is 0.032 per cent, with an average deviation of 0.002; for sulphur (same position) the average is 0.047

bon content of 0.645 per cent (sink-head 0.648 per cent), with an average deviation from mean of 0.036. The manganese content is 0.70 per cent, as compared with 0.89 per cent for the sink-head ingots, phosphorus 0.019 per cent (sink-head 0.047 per cent). Group M11 to M15 has an average phosphorus content of 0.028 per cent, which quite closely agrees with that of English-cast ingots. This sub-group is also from its method of manufacture the best to compare with the imported ingots.

The sulphur content of the comparison ingots fol-

lows the grouping by heats; the tread analysis of the C rail, for example, for ingots M1 to M5, has a sulphur content of 0.076 per cent; for ingots M6 to M10, the sulphur is 0.101 per cent; for ingots M11 to M15, the sulphur is 0.118 per cent. The manganese and silicon of the first two groups are practically identical, while both are slightly higher in the third group (M11 to M15). Chromium and nickel are practically constant at 0.28 per cent for the former and 0.75 per cent for the latter for all three groups.

DISPOSITION OF INGOTS

Of the thirty-seven sink-head ingots cast at Sheffield, thirty-five were rolled into blooms at the Sparrows Point mill and the remaining two ingots were sectioned longitudinally for metallographic examination. The examination of H32 was made by the Bureau of Standards and H37 by Hadfields, Ltd. In addition to splitting two ingots, it was also decided to examine similarly top blooms from one of each of the two types of ingot (H5 and M10). The blooms and ingots examined in this manner were selected at random. All blooms were rolled into rails directly without reheating and all material was accounted for by actual weighing.

BLOOMING MILL

All ingots were rolled in thirteen passes in a two-high mill to blooms 8 x 8½ in. The English-made ingots entered the blooming mill with the sink-head toward the rolls, one-half receiving the first or "squaring up" pass in this direction, no draft being given on second pass, while the other half were given no draft on the first pass, the "squaring up" being done on pass No. 2. The Maryland ingots were rolled according to ordinary practice entering the rolls the small end first.

BLOOMS

Each ingot was cut into two blooms (8 x 8½ in.) as shown in Fig. 2, and rolled directly into rails —that is, without reheating of blooms. The second bloom from sink-head ingots made two rails (C and D), and that from Maryland ingots three rails (C, D and E). The first bloom from the sink-head type of ingot made a B and (generally) a short A rail; the first bloom from the comparison type of ingot made a B, A and (short) *x* rail. The blooms were sheared top and bottom as little as possible for the safe passage of the bar through the rolls. Each piece cut was marked, weighed and preserved.

RAILS

In the rail mill there are six passes in the roughing rolls, four in the intermediate rolls and one finishing pass, making a total of twenty-four passes from ingot to finished rail. The rails, which were Pennsylvania 100-lb. section, were cut at the hot saw as shown in Fig. 2.

The rails were inspected for surface defects, piping and discard to physically sound steel. The classification into "firsts" and "seconds" from surface conditions was made by the Pennsylvania Railroad Co. inspectors; the discard to "physically sound steel" was made by cutting back in 5-ft. lengths.

There were a relatively large number of "second" rails from the sink-head ingots, sixty-one out of a total 104 rails, or 59 per cent. There were only four in fifty-seven from the comparison ingots, or 7 per cent. The A rails are not included for either group.

There appears to be no reason why ingots of the sink-head type should not be as well surfaced as any other, and the high percentage of seconds should not be attributed to the type of ingot, as the bottom of the sink-head was well within the "A" rail, which was not classified. Probably the severe and unusual reheating conditions contributed somewhat together with the original surface condition as influenced by condition of the molds and teeming practice, toward producing the large number of "seconds" from the Hadfield ingots. A large percentage of "seconds" was similarly obtained from the reheated Hadfield ingots reported on by Hadfield and Burgess[1].

(Parts II and III will be published later.)

Free Thiocyanogen

BY CLARENCE JAY WEST

In 1815 Gay-Lussac discovered that cyanogen, C_2N_2, could be prepared and that it was capable of existing in the free state. This was the first organic "compound radical" discovered. Cyanogen was called a radical by Liebig because

1. It is a never varying constituent in a series of compounds.
2. It can be replaced in these compounds by other simple bodies.
3. In its compounds with a simple body this latter may be easily separated or replaced by equivalent quantities of other simple bodies.

Of these three chief and characteristic conditions of a compound radical at least two must be fulfilled if the substance is to be regarded as a true compound radical.

Other compound radicals which are well known are nitrogen peroxide, NO_2, sulphur dioxide, SO_2, etc.

Following the discovery of cyanogen, Liebig in 1829 undertook to prepare free thiocyanogen by the action of chlorine upon silver, lead and potassium thiocyanates under various conditions, but was unsuccessful. The next step came when Linnemann (1861) shook an ether solution of iodine with silver thiocyanate. Silver iodide was formed, but the substance in solution decomposed so easily that it was not studied.

That free thiocyanogen was really present in this ether solution has been shown by the recent work of Söderbäck [*Ann.*, vol. 419, p. 217 (1919)]. He has shown that chlorine, bromine or iodine acting on a number of metallic thiocyanates such as silver, lead, mercuric, cadmium, zinc and cuprous, in a variety of solvents such as ethyl chloride, ethyl bromide, carbon disulphide, carbon tetrachloride, benzene, absolute ether, etc., yields a precipitate of the metal halide and a solution containing free thiocyanogen. The substance is best isolated from about a twice normal solution in carbon disulphide, by cooling with ether and liquid CO_2, and by filtering in a funnel cooled in the same way. Thiocyanogen forms rhombic plates, white to pale yellow in color, which melt at —2 to —3 deg., to a pale yellow liquid. These may be supercooled to —20 deg., but at —30 deg. always solidify. The liquid is unstable and quickly decomposes, changing from yellow to a dark reddish brown. While the crystals are soluble in organic solvents, water decomposes them, yielding thiocyanic acid, HCNS, hydrocyanic acid, HCN, and sulphuric acid. Söderbäck believes the molecular formula to be $(SCN)_2$, from its reaction with hydrochloric acid.

Arthur D. Little, Inc.,
Boston, Mass.

[1]See reference on p. 921.

Education of the Engineer

**In Fifty Years Engineering Has Become a Learned Profession, a Wonderful Advance Considering the
Conservatism and Complacency of Educators and Public—Yet No Better Engineers
Are Being Produced, Largely Because of Inattention to Fundamentals**

By ROBERT S. WOODWARD*

WHEN I left the University of Michigan forty-eight years ago I found, much to my surprise and chagrin, that people whom I took to be the best educated people of the time led me to believe that there was no prospect that a man who has this elementary training we call engineering could become either a scholar or a gentleman. The nearly universal opinion was that the only way to achieve those desirable ends was to pursue a course of study which led to the degree of A.B. It was thought that the pursuit of studies in mathematics, say, beyond the confines of Euclidean geometry, would be narrowing in their influences, and that prejudice, I am sorry to say, has persisted in some quarters even to this day.

ENGINEERING NOW A LEARNED PROFESSION

Few of you young men who are here can realize the great change that has taken place since then. The engineer has now come to be recognized as a member of a learned profession. In those old days there were only three learned professions recognized—those of law, medicine and theology. The great class of people whom we then called humanists, and whom we still call humanists, were separate and apart from the professional classes, and they, in those days as in these, held themselves to be far above the groveling crowd, even in professional matters. But in the meantime great progress has been made, and I think perhaps you may be interested to know what, in a brief statement, is my verdict as to the reason why you have achieved so much. To put it in a homely way, such as was used in New York City when I dealt somewhat in Tammany politics, the chief reason for your success is that you have been willing to "say little and saw wood." In other words, you have been willing to have your measure taken by merit alone, and that, in the long run, is the only ground on which a man may be expected to stand with any degree of permanence.

The title of my address, assigned to me, by the way, is "Education of the Engineer." But I fear that some of you don't know that in respect to education I am both a Philistine and an iconoclast. I have been at war with education all my life. I think in the courts it would have been said, if my testimony had been solicited, that I was a recalcitrant witness. I am disposed to think, although I have been connected with three universities, including the University of Michigan, and have been not lacking in experience as professor and as administrator in educational affairs, that the general verdict would be that I am far from orthodox; so that if I vent some of my spleen, you should not be surprised.

However, I am disposed to think that agitation is a good thing, and one of the things we must have; after the fashion of the Irish politician in Philadelphia, I have come to think, as he put it, "It is well for one to let folks have what they wants." And so, perhaps, it is well, if not inevitable, that what we call education should be what it is. I am going to indicate to you some of the faults I have to find with current education, not that I expect any rapid changes will take place, for the business of education is the most conservative business with which men are concerned. First, let me remark on this peculiarity of Americans: with us education is a passion. There is no interest which is so dear to the heart of our average American as education. We can raise money for almost any kind of a scheme in education. On the whole I think that has been a good thing, but it has not been without its sinister effects.

Another peculiarity about education is that it is a subject of perennial interest. There are coming on crops of successive individuals and generations who come to the subject as if it were entirely new; as if all that need be learned had to be learned by them; and I think it must be admitted that all they learn is learned by them; they cannot learn from other people. But the fact that our young folks come to the subject of education with such assurance and with such optimism illustrates a general fact with regard to that sort of knowledge we call history.

It is a curious and a depressing fact, when we come to think of it, as an old man like me sometimes thinks about it, that we learn less from history than from any other source of human knowledge. Perhaps you would be inclined to dispute that. But have we not had to witness it? One of the most extraordinary examples in all history is furnished by the Paris Peace Conference. Haven't things been set up temporarily or adjusted at that Conference as if there had not existed twenty centuries of recorded history? Wasn't that Conference one which proceeded as if we had had no previous experience in international law, or in economics, or in anthropology? I think that furnishes the most striking illustration in the whole history of mankind of the fact that we learn almost nothing from history.

"LAW OF THE CONSERVATION OF IGNORANCE"

Turning now from this more serious aspect of my subject to something which is more humorous: Do we not find this fact illustrated in education? Things go on about the same. Our standard courses of education in the colleges and universities are about the same as they were five or six or seven hundred years ago. We have gone on with very little change; and it is probable we shall go on in much the same fashion. In one of my addresses read at Columbia University I made some reference to this subject, and I said our procedure with respect to education is strictly in accordance with the

"law of the conservation of ignorance." If you care to look up the subject, you will find that I have elaborated that statement and explained how it happens. There are good anthropological reasons for the statement we proceed in accordance with the "law of the conservation of ignorance."

EDUCATORS COMPLACENT IN REGARD TO EDUCATION

Let me refer to another aspect of education in general. Is there anything concerning which we, as educators—and now I speak as an ex-professor and as an ex-dean—is there anything with regard to which we are more complacent than we are with regard to education? And is it not now being sounded from a thousand platforms? There must be a thousand degree-giving establishments in the United States. From a thousand platforms we may now hear it said that "education makes the man." No proposition can be more nearly wrong than that. I flatly contradict all such statements. Yet we listen to it from year to year with the utmost complacency, with a spirit of serene opacity. Nothing can shake our confidence in our systems of education. Our confidence in education is perhaps most strikingly illustrated, if quantity of noise is a measure, by our monthly, semi-annual and other dinners—alumni dinners. Who has not attended a number of these, and who has not discovered in them a striking similarity to Mr. Bryan's brief description of an old-fashioned Jeffersonian or Jacksonian dinner? When we get together on these occasions, some sing, some dance, some speak, but most of us whoop like wild Indians, with a degree of confidence which shows that we have not the slightest pangs of conscience with regard to what we call education.

MANY HUMOROUS ASPECTS TO "EDUCATION"

But why raise any such questions as these now? This, of all times, is perhaps the most inappropriate occasion to raise a question concerning the curricula; even the curricula of engineering schools, or questions with regard to the conflict of study, or questions with regard to the requirements for degrees. I would be the last to raise any doubt concerning these, because all such technical matters have been settled with a high degree of exactness by our academic friends. They have got the number of points a man or a woman must make down so fine that they express them to four significant figures. It must be evident, then, that it is nearly useless to inquire into these questions, because it must have been settled by our teachers and by the heads of our colleges and universities just what is necessary to make an educated man. Nevertheless, to an old fellow like me, who has been both inside and outside these camps, there are many things that tend to make one laugh, and I trust that whatever I may have to say or have said in criticisim of education will not be taken too seriously. I am sure of this, that whatever I say will produce only the slightest effect; yes, an effect which will be purely ephemeral. Nevertheless, there are some very funny things to be found in education; some fallacies that any hard-headed student could easily puncture. But I am disposed to pass these matters over, partly because we engineers have a society for the promotion of engineering education, which has also settled all these points. Yet I think you will agree with me that in spite of all the energetic and active work that society has done, we are not turning out any better engineers now than we turned out

fifty years ago. Do you ask the question why it is that we are not turning out any abler men now than we did fifty years ago? Well, I think it is worth while for us to ask and to try to answer that question.

Here is another question raised by my friend President Eliot, emeritus of Harvard, who created quite a stir in military circles a few weeks ago when he stated that the selection of the men for the work of the Naval and Military academies was not good. I think that statement is obvious. If you wanted to select a good able body of engineers, you would not ask Congressmen to name the men to become graduates of these great schools. Look at the product, however. You must judge institutions and organizations by their products and not by any more refined method. I agree fully with Dr. Eliot, but at the same time I think both parties are right. Where is the paradox? There is a paradox, and it leads me to come to my first point concerning education.

Here is my first proposition: Education does not consist in studying certain things. It consists rather in studying some things thoroughly well. And then my next proposition is that our boys and girls turn out fairly well from educational establishments, not by reason of them, but in spite of them.

The important factor which we educationalists have from time immemorial overlooked is that of heredity; what a man will be when he goes through this, that or the other college depends far less upon the college than the man's inheritance. To put the case in another way, we only need to refer to the formula for the generation of a gentleman furnished by Oliver Wendell Holmes. You know Holmes said, "If you want to generate a gentleman, you must begin 400 years before he is born." Well, so it is in education. Our boys and girls turn out fairly well from the colleges and universities, not by reason of them, but in spite of them. They turn out well because they are on the average of good stock, and that explains why it is that the men from the schools of West Point and Annapolis are, on the whole, able and praiseworthy men.

THOROUGH TRAINING NEEDED FOR SPECIALISTS

It would be easy to cite many illustrations of the fallacies to which I have referred. You know our old and dominating predecessors in the educational world—namely, the humanists—claim that a man, in order to be educated, must study certain things, and particularly certain things in strictly limited quantities. For example, if he pursue mathematics beyond the elements of algebra and the elements of Euclidean geometry, he is stigmatized by our friends and humanists as a narrow specialist. There is something very ridiculous about that common phrase. I think it would be more logical and more polite to say that the training of the specialist —I don't mean the dilettante, but the specialist who knows more than other people about a subject—must be broadly liberal in order that it may be minutely special. And as to that more general proposition I referred to, that "education makes the man," I think it ought to be replaced by this proposition. It is very simple, perhaps too simple—Man makes the education. That is all there is to it, when we come to sift it all down and let the wind out of it. What a man is will depend chiefly upon his industry and upon the capacities which he has inherited from his forefathers.

But some of our critics with regard to engineering education have special charges to bring against students

of engineering. It is alleged they are not only narrow specialists, but that they do not know English; they do not know how to pronounce their own language; they are unable to write their own language. Now, all that is true. It is worse than that. It is a truism and hence a platitude, because there are very few people, however they may be educated, who can speak the English language correctly, or speak any language correctly, and there are very few who can use it with skill. Some of my friends have heard engineers make some very serious mistakes which they would not have made if they had known a little of Greek. To take an example as an illustration, a very little knowledge of Greek would enable a man to say "aëroplane" instead of "air-e-o-plane"; but a much less knowledge of spelling would enable him to know the same thing; and as anybody who pays attention may see, there are about as many who have studied Greek who make this vulgar error as there are those who have not studied Greek. Similarly, in these days we hear much said about science and research, but, as you know, this word research is almost universally mispronounced. It is one of the 25,000 words that are commonly mispronounced. We in our American impetuosity have advanced the accent of that word to a position not yet approved by the lexicographer. But I find that people who have studied Greek and Latin, and who have had all the advantages of classical learning, are about as apt to use "re' search" as other folks. So I conclude that the correction for these errors is not to be found in studying certain things, but is to be found in the slow and painful process of generating men and women who will give attention to words. If a man is a good speller he must give attention to the spelling of words. No amount of study in Latin or Greek or Sanskrit or Choctaw will help him very much. So, if a man is going to be successful as a lawyer, as a doctor, as an engineer, his success will not depend upon his having studied certain things, but it will depend upon the degree of attention which he gives to the things which are before him, concerning which he needs to know.

A short time ago I had a humorous illustration of the serene confidence of a good friend, a humanist, in his learning when he stood alongside an automobile and awaited the opening of the hood to look in on that physical laboratory which we now call the engine of an automobile. He had never given any attention to such subjects, and he was very glad he had a negro chauffeur who did know a little about it. Something had gone wrong with the engine, and it was necessary to find what was wrong. Well, after pacing up and down alongside the hood of the automobile, he turned to me and said, "*Ultra vires*"! Undoubtedly what needed to be done to that engine was beyond him. That illustrates how easy it is for us to be content with little knowledge of some things and to imagine ourselves lords of the universe.

I have two or three faults to find with our engineers. You know that a long time ago John Stuart Mill emitted in one of his books that aphorism, "A man ceases to be progressive as soon as he feels that he is king of his company." Now, during the past fifty years, the engineers have made extraordinary progress. They have come into their own, and some of them have come to feel their sufficiency, and what I fear is that some of us are in danger of making the same classic errors made by our friends the humanists. I occasionally hear some of our engineers assert that if we could

only have the affairs of the world turned over to us we could make them go a good deal better than they are now going; and while there is much truth in this, I suspect there is some degree of error in it, and that having seen a number of classes of predecessors fall into this crass error, it would be well for us to take note of it and try to avoid it in the engineering profession.

In line with that, I would like to say that one fault I find with our schools of engineering now is that they are devoting very little time to research. I think it is a characteristic fault of the schools of engineering in our country that they are willing to take what they can get from other sources, and not cultivate a capacity for original investigation, and have that sort of progress which comes from research. There are a few schools in the United States—and there are individuals—who during their leisure time carry on important researches, but I do not think there are any more such today than there were forty years ago.

This is especially to be regretted at this time, because now is the time of great opportunities for the American engineer. I would like to see a school, or a high school of engineering perhaps we should say, after the French model, for the prosecution of engineering studies, something comparable with the Ecole Polytechnique of Paris. Some of you may not be aware of the fact that a very considerable proportion of the leading engineers in the history of the world have come from the Ecole Polytechnique. Great names are connected with that school. Going back 100 years ago, there were Lagrange, Laplace and Poisson, who laid the foundations of mathematical physics; then a little later came that great aggregation of engineers beginning with Navier, who laid the foundations and built the superstructure of that extraordinary branch of mathematical physics which we call the theory of elasticity, a branch of mathematical physics far and away greater than Einstein's theory, which has attracted so much attention in the past six months.

Now, the thing I want to call your attention to, and especially you young men with whom the future of engineering education largely rests, is that we need to have in our country somewhere, somehow, a great school for theoretical study, which may become comparable with the Ecole Polytechnique. This is not only a great opportunity, but a great duty before us.

A Study of the Hardness of Glazes by the U. S. Bureau of Standards

An attempt is being made to differentiate the different glazes applied to clay products according to their hardness by tests similar to the Brinell test commonly used for metals. The hardened steel sphere used in the Brinell machine is replaced in this case by a conical steel point, the penetration of which into the glaze under high pressure is an index of the hardness of the material. This penetration is measured by means of a micrometer microscope. The pressures employed for forcing the point into the glaze are quite high and have been as great as several hundred thousand pounds per square inch. Although the test has not yet been brought to a satisfactory status, it has differentiated between the several types of enamels and glazes examined. Thus enamels are punctured under fairly low pressures while high-fire porcelain glazes are exceedingly resistant, and white ware glazes occupy an intermediate position.

The Manufacture of Lime for Chemical and Metallurgical Purposes*—III

Methods of Heating Rotary Kilns — Description and Comparison of Pulverized Coal and Producer Gas Installations — Boilers in Series With Kiln — Power Consumption—Cost Data†

By RICHARD K. MEADE

PULVERIZED coal, producer gas, natural gas and oil are all employed for heating kilns. Localities where natural gas can be used are few and the cost of oil at the present time is prohibitive in most sections of the country, so the fuels generally available are pulverized coal and producer gas. Natural gas is the most convenient fuel and producer gas the most troublesome. Oil is a very convenient fuel to use and the installation also costs less, except where very large storage tanks have to be provided. When oil is used for a fuel, the apparatus necessary to heat the kiln is similar to that required for heating a boiler with this fuel. Almost any type of burner which will atomize the oil and give a conical flame will work satisfactorily. The writer has used Rockwell, Hauck and Kirkwood burners with success. He has also obtained equally good results with a burner which he had made up from his own design out of ordinary pipe and fittings. In all of his installations, he has employed air at from 30 to 40 lb. pressure not only for atomizing the oil but also for forcing it to the burners. In his system there are, in addition to the main storage tank, two small supply tanks, each of which will hold a supply of oil sufficient to last the kiln for from four to six hours and which are capable of withstanding a pressure of 100 to 125 lb. The two tanks are used so that one will be in service while the other one is being filled. The oil is forced from these tanks to the burner by means of compressed air, just as acids are lifted. The writer's experience has been that high-pressure air atomizes the oil better than low-pressure air and the use of air to force the oil to the burners does away with the oil pumps and allows one apparatus to do the work of two.

Owing to the difficulty of securing oil cheaply in most localities, the average lime manufacturer, as I said, will have to decide the question of whether he will use pulverized coal or producer gas for heating the kiln. There are some points in favor of each. Producer gas will give the purest quality of lime. Pulverized coal, on the other hand, will be more economical and easier to handle.

PRODUCER GAS

Producer gas burns a nice clean lime. The temperature of the flame obtained is ample to burn good chemical lime and if the producer is a good one and is well taken care of, fairly uniformly burned lime, free from core, will be obtained. Producer gas, however, varies with the operation of the producer. The hand-fed, hand-rabbled producers give a gas the quality of which depends very largely on the man who operates

them. When such a producer is freshly charged with coal there is a rush of gas through the furnace. The gas then gradually decreases in calorific power until the next charge of coal is put in the producer. Automatically stoked and fed producers operate much more smoothly and if at all well handled this objection is practically eliminated.

The producer should be located under a bunker so that the coal may be fed directly into the hopper of the former. Arrangements should also be made for removing the ashes conveniently. The producer should be located near the kiln so that no more heat will be lost by radiation than is absolutely necessary. The piping should be so arranged that the flues can be cleaned easily. Usually each kiln has its own producer or producers and no valves are inserted between the kiln and producer, the rate at which the producer is operated
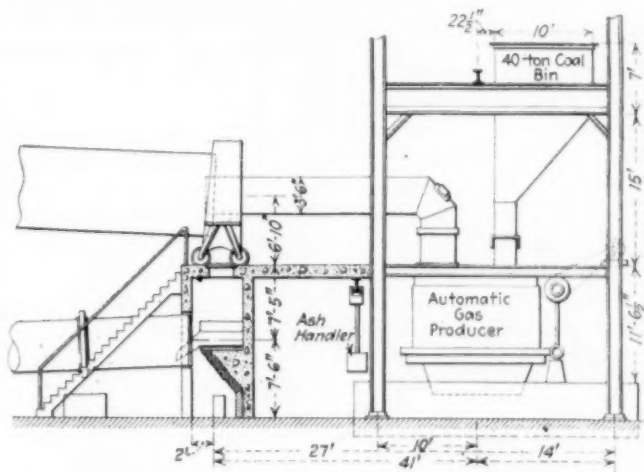
FIG. 7. PRODUCER GAS INSTALLATION

controlling the flow of gas to the kiln. Where two or more small kilns or other furnaces are heated from the one producer, etc., valves will, of course, be necessary. In the event a valve is not used, a sand damper or some means of shutting off entirely the producer from the kiln should be provided so that the lining of the latter may be repaired when desired without allowing the fire in the producer to go out. Fig. 7 illustrates the installation of a gas producer in connection with a kiln.

As an 8 x 125-ft. kiln will require from twenty to twenty-five tons of coal to heat it, or a gasification of about 2,000 lb. of coal per hour, it will be seen that one kiln is large enough to have its own producer or producers and one large kiln is always to be preferred to several small ones.

The largest mechanically stoked producers will take care of from 3,000 to 3,500 lb. of coal per hour, or

about thirty-two to forty-four tons per day, but much smaller producers can be obtained with the automatic feed and stoking arrangement.

About 0.4 lb. of steam will be required to operate the producer for each pound of coal gasified. This is equivalent to approximately one boiler-horsepower per ton of coal gasified in twenty-four hours. Or an 8 x 125-ft. kiln would require twenty to twenty-five boiler-horsepower.

One man per shift can take care of a mechanically stoked producer with the help of another man part of one shift to get coal into the bunker. take away the ashes, etc.

I estimate that the cost of producer gas in a well-equipped plant is approximately as follows, figuring on a producer which will gasify 2,000 lb. hourly:

Attendants, 1 man @ $4, 3 shifts	$12 00
Attendants, 1 man @ $3.20, 1 shift	3.20
Steam, coal @ $5.	6 00
Supplies, repairs, etc.	5 00
Cost per 24 tons of coal gasified	$26 20
Cost per ton	$1 09

Added to the above should be the losses from the producer. With smaller producers, cost of attendance would, of course, be more per ton, which would raise the cost of the gas.

COMPARISON OF PRODUCER GAS AND PULVERIZED COAL FIRED OPERATION

The advantages which pulverized coal has over producer gas for heating rotary limekilns are, first, the much more uniform rate of supply of fuel to the furnace, as where proper feeding devices are used there is a continual supply of fuel to the furnace at a regular and uniform rate, and this fuel is, of course, of the same thermal value at all times and does not vary in this as does gas. Second, with powdered coal the loss of carbon due to that remaining in the ash is avoided. Third, it is possible to burn powdered coal with almost the exact quantity of air necessary for combustion, which is not possible with producer gas. This means a higher flame temperature and a saving of fuel. Fourth, in the producer there is a loss of coal due to carbon completely burned to carbon dioxide. A certain portion of this loss is of course conserved as sensible heat in the gas and is utilized provided the producer is set close enough to the kiln to cut down radiation losses.

The efficiency of a producer is seldom greater than 85 per cent and is generally less than this compared with pulverized coal.

Experiments which the writer has made indicate that when pulverized coal is used about 40 per cent of the ash of the fuel enters the lime. Assuming, therefore, that 450 lb. of coal is required to burn a ton of lime and that the ash amounts to 10 per cent of the weight of the coal, one ton of lime would contain 18 lb. of ash, or about 0.9 per cent. I am giving herewith two analyses showing lime burned with pulverized coal containing 11 per cent ash and what the same lime would be burned with producer gas.

A larger amount of ash will be retained by lime in which there is a lot of fine material, such as where the fine limestone dust has not been screened out, than will remain where the dust is screened from the coarse stone. The dust seems to catch and hold the ash rather than to allow it to be carried away by the draft of the kiln.

The cost of pulverizing twenty-four tons of coal daily is approximately as follows:

Drying the coal — 0.2 tons coal @ $5	$1.00
Attendants — 1 man, 1 shift, 8 hours @ $4	4.00
Grinding 400 kw.-hr. @ 2c	8.00
Supplies, repairs, etc.	4.00
Cost of pulverizing 24 tons	$17.00
Cost per ton	$0.71

It is hardly necessary in this paper to go into the various methods for pulverizing coal. The subject has been dwelt on quite extensively in technical literature the last few years.[1]

PULVERIZED COAL INSTALLATIONS

Sufficient to say, two general systems may be employed for heating the kiln with pulverized coal. One system in which the coal is pulverized and blown into the kiln at the same operation and the other in which the coal
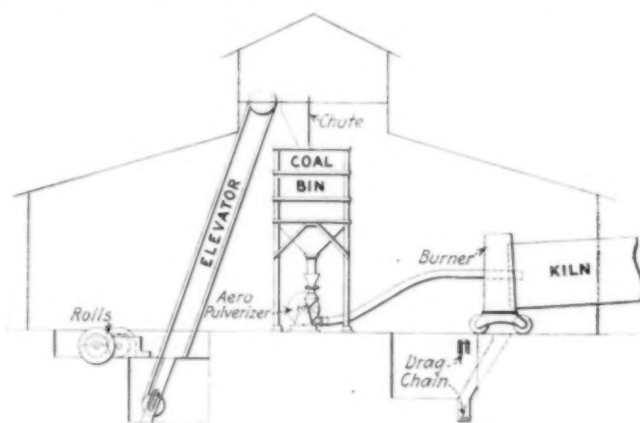
FIG. 8. ROTARY KILN HEATED BY AERO PULVERIZER

is pulverized in a separate plant, the pulverized coal conveyed into a bin at the kiln and fed from this into the burner as desired.

Fig. 8 shows the former installation in which an "Aëro" Pulverizer is used. This latter consists of a series of paddles which revolve about a horizontal axis in circular chambers through which air is drawn by means of a fan on the same shaft as the paddles. The coal is pulverized by being thrown against the walls of the chambers by the paddles and is drawn out with the necessary air for combustion and blown directly into the kiln through a pipe which extends directly from the pulverizer to the kiln. This pulverizer is supposed to work on damp coal and with Eastern coals has given fairly good satisfaction without drying the coal. With some of the coals in the Middle West, however, the experience has not been so good. The Aëro requires about 18 hp.-hr. (13½ kw.-hr.) per 1,000 lb. of coal pulverized, or with ordinary fuel consumption about 7½ hp.-hr. (5½ kw.-hr.) per ton of lime produced. It should be remembered in comparing this power with that required by other machines that the above includes power necessary to blow the coal into the kiln, etc. This machine may be looked upon as a cheap method of

COMPARISON OF LIME BURNED WITH PRODUCER GAS AND PULVERIZED COAL

	Analysis of Lime Burned With	
	Pulverized Coal	Producer Gas
Silica	2.44	2 10
Iron oxide and alumina	1.15	0.80
Lime	94 33	95 00
Magnesia	1 22	1 24
Loss on ignition	0.86	0 86

[1] See Meade, *Transactions* of American Institute of Chemical Engineers, vol. I, p. 98.

heating the kiln with pulverized coal rather than as the most efficient, as it does not pulverize the coal very finely.

The best method of preparing the coal and the one which would probably be used by a large lime plant would be to pulverize the coal with either Raymond or Fuller mills and convey it into a suitable storage bin, from which it would be fed to the kiln as required. Fig. 9 illustrates this system, a Raymond mill being used.

Either one of these two pulverizers will require the

FIG. 9   ROTARY KILN WITH SEPARATE COAL PULVERIZING PLANT

coal to be crushed to about 1 in. and to have been dried. The Aëro Pulverizer will also require that the coal be reduced to 1 in. For crushing the coal a set of rolls is usually employed and the drying may be done in any of the accepted types of rotary coal driers.

The coal bin should hold sufficient coal to last the kiln sixteen to twenty-four hours so that the pulverized coal plant need not be operated more than one shift. The coal is fed out of the bin at a uniform rate by means of a worm, the speed of which can be altered to give the desired amount, and dropped into the burner. Either steam or high- or low-pressure air may be employed to blow the coal into the furnace. Low-pressure air at 6 to 10 oz. from an ordinary blower is usually employed, about 50 per cent of that necessary for combustion being so supplied.

BOILERS IN SERIES WITH KILN

The waste gases leave the kiln at about 1,300 deg. F. and hence contain a large part of the heat liberated by the burning of the fuel. This heat can be successfully utilized in boilers, as has been done in the cement industry[2] where an efficiency of 70 per cent has been obtained. The weight of gases usually amounts to between 6,500 and 7,500 lb. per ton of lime produced. The heat in the same will, therefore, be approximately 2,275,000 B.t.u. This is about 40 per cent of the total energy of the coal burned, the remaining 60 per cent being dis-

See Baylor, *Transactions* of the American Institute of Chemical Engineers, vol. 10, p. 209.

tributed about as follows: Decomposition of the limestone, 54 per cent; radiation from the shell, 6 per cent. Of this waste heat 70 per cent has been successfully utilized by waste heat boilers, or about 1,500,000 B.t.u. per ton of lime produced. This is equivalent to 1,550 lb. of steam at and from 212 deg. F., or 45 boiler-horsepower (hours). A kiln burning four tons of lime per hour, therefore, would be good for about 180 hp. In the new lime plant of the Eastern Potash Corporation, designed by the writer, boilers are being installed. In most chemical plants where steam is needed for evaporation the plan should certainly be employed, as not only power enough to operate the kiln can be obtained but considerable in excess.

FUEL CONSUMPTION

The fuel requirements of a rotary kiln are from 2,800 to 3,500 B.t.u. or 400 to 500 lb. of coal per ton of lime, 37 to 45 gal. of oil per ton of lime, 500,000 to 625,000 cu.ft. of natural gas per ton of lime.

This is better than can be accomplished with the best hand-fired kilns and but slightly less than that claimed for the best types of gas-fired kilns. The quantity of fuel required depends, just as in the case of the vertical kilns, upon the nature of the stone, the kind and quality of the fuel, the skill of the operator and the kiln itself. The most economical kiln is one in which the ratio between length and diameter is greatest. That is to say, of two kilns having the same diameter but different lengths operated under the same conditions, the longer kiln will have the greater fuel economy (and incidentally the greater output also).

If we deduct the fuel required to produce this power from that required to burn the lime, the efficiency of the rotary kiln will far exceed any other type. To produce 180 hp. about 720 lb. of coal per hour will be required, while to heat the kilns 1,800 lb. of coal per hour will be required, leaving 1,080 lb. of coal charged against the lime burning—or 7.4 lb. of lime per pound of coal.

Where the gases from the kiln are needed in the chemical process they can be drawn off from the kiln stack by means of a fan. Generally speaking, the gases from a rotary kiln are not quite so rich in carbon dioxide as those from a vertical kiln due to the leak through the annular space where the kiln revolves in the stack chamber. By proper arrangements for closing up this opening as much as possible, a gas containing about 24 per cent carbon dioxide on an average can be obtained. The waste gas always contains dust consisting of particles of limestone and lime and, if pulverized coal has been used for burning, the ash of this coal. The gases may be cleaned practically free of this by the use of water sprays, gas washers, etc.

One man can attend to the kiln provided the stone is placed in the feed bin for him. If there are more than one kiln, one man and one assistant can attend

to as many as three kilns. If the Aëro is employed to pulverize the coal, the kiln tender looks after this also. The coal, however, should be placed in the bin above this for him, so that all he has to do is to see to the proper operation of the kiln, cooler and pulverizer. Any intelligent man can be broken in to operate the kiln in a satisfactory manner.

POWER CONSUMPTION

The power required to operate a rotary-kiln plant will be about as follows per ton of lime produced:

	Hp.-hr.	Kw.-hr.
To crush limestone	2.50	1.9
To revolve kiln, feeder, etc	4.25	3.2
To revolve cooler	1.25	1.0
To pulverize coal, separate plant	5.50	4.1
To feed and blow coal into kiln	2.00	1.5
To pulverize coal, Aëro system	8.00	6.0
Miscellaneous, stone elevator	1.00	0.8
Total where pulverized coal is used	16.50	12.5

Repairs to the kiln are light and consist in an occasional renewal of the lining at the lower 20 or 25 ft. of the kiln. The lining of the upper part of the kiln will last for many years, but in the hottest part of the kiln the lining must be renewed every six to nine months, although a careless attendant can burn out a lining in a few weeks' time. An allowance of 25c. per ton will easily take care of repairs to the kiln, relining

when necessary and the lubricants, provided the kiln is properly handled. Under existing conditions a rotary-kiln lime plant of the best construction will cost approximately $950 per ton of lime produced per day. This figure includes a steel building entirely over the kiln and a pulverized coal plant or mechanically stirred producer. Where an Aëro Pulverizer or oil fuel is employed the cost is slightly less. It is not absolutely necessary to cover the whole kiln with a building. If this is not done, of course, the cost will be reduced.

The cost of producing lime in a rotary-kiln plant in the Middle Eastern States at this time is about as shown in the accompanying table. The first column rep-

COST SHEET OF A ROTARY-KILN LIME PLANT

Stone, 2 tons	$1.50 to $2.50
Coal, 0.2 ton	1.00 to 1.50
Labor	.20 to .60
Power, 15 kw.-hr. at 2c	.30 to .45
Repairs, supplies, etc	.25 to .35
Total	$3.25 to $5.40

resents cost with an output of 100 tons daily, stone quarried at the plant and a coal at $5 per ton. The second column represents cost with a 30-ton plant where stone is purchased and coal costs $7.50 per ton.

Glueing Turpentine Barrels

Turpentine will readily penetrate through the staves of an ordinary wooden barrel. It is therefore necessary to coat the inner surface of the barrel with ordinary glue, which is insoluble in turpentine but readily soluble in water, say naval stores experts of the Bureau of Chemistry, United States Department of Agriculture. Turpentine soon leaks out from a barrel that has been carelessly or improperly glued, as well as from one containing any water, regardless of how well the glue was prepared or applied. Consequently great care must be taken in preparing the glue and applying it to the barrel, and finally also in so filling the barrel with turpentine that no water gets into it.

As a rule, glue makers furnish with their product a formula showing the proper proportions of glue and water. The following formula is recommended by one of the largest producers of animal glue:

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Glue, lb. .......................................20
Water, gal. ......................................8
Commercial borax, powdered, lb..................  ½
Commercial glycerine, lb........................  ¾
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The glycerine is added to make the glue more elastic, and may be omitted if the directions for preparing the glue here given are carefully followed.

Late in the afternoon place the quantity of glue required for the next day's work in a perfectly clean jacketed or double-boiler glue kettle, cover with the proper quantity of clean cold water, and let it dissolve slowly to a jelly. When glue prepared in this way is heated the next morning, it dissolves in the water rapidly and smoothly, and has the further advantage of being somewhat stronger than that simply mixed with cold or hot water and immediately heated.

Since animal glue rapidly loses its adhesive strength when it is subjected to a high temperature, it should never be boiled. Glue prepared in a single unjacketed kettle over an open fire will almost certainly become too hot and boil when not watched, or it will not be hot enough to glue the barrels properly without waste. In preparing the glue, then, use a double boiler or jacketed glue kettle. The boiling water in the lower pot heats

the glue in the upper pot to the proper temperature without bringing it to a boil. Do not keep the glue hot longer than necessary. Have the barrels ready to glue as soon as the glue is hot, glue at once, and clean the glue kettle for the next day.

Before glueing the barrel, drive the hoops down moderately tight. Then pour about 1 gal. of the hot glue into the barrel, plug up the bunghole, and sluice the barrel around well, making sure that the glue comes into contact with every bit of the inside surface. Remove the stopper, place the barrel on a rack over the glue kettle, and allow the excess glue to drain directly into the kettle. As soon as most of the excess glue has drained out, take the barrel from the rack, and stand it on one head in a level place. About one-half hour later, drive the hoops down absolutely tight, so that the tension on the hoops all around the barrel will be equal, and let it stand on the same head, thus permitting some of the soft glue still inside the barrel to settle down in the chine, where most of the leaks occur. Allow the barrel to stand, bung open, for several days under a shed, protected from the sun and rain, and then glue again exactly as before, but making sure that the barrel stands on the other head this time. After two days the barrel is ready for use. Barrels glued in this way should give little if any trouble from leaking, provided no water is allowed to get in.

As animal glue is extremely subject to decomposition through the action of bacteria and molds from the air, glue left in an open kettle soon begins to decompose, as shown by its foul odor, thus becoming no longer fit for use. It is, therefore, highly important to keep any leftover glue sweet and clean if it is to be used again. The unused glue should be poured into a can which may be tightly covered and stored in a cool place, and the pot thoroughly cleaned. Fresh glue is ruined if put in a filthy pot containing decomposed, foul-smelling material. The borax recommended in the formula is to help keep it sweet, and should be dissolved in the glue when ready for use.

Electric Furnace Refractories*

A Brief Description of the Raw Materials Now Available for Highest-Grade Brick, Together With a List Showing Recommended Refractories for Melting the Different Metals and Alloys, and Practical Hints on the Care, Storage and Laying of Roofs, Hearths and Linings

By A. F. GREAVES-WALKER†

ONE of the most important problems facing manufacturers and operators of electric furnaces at the present time is that of refractories for linings and roofs.

The greatest advancement in furnace design and usage came during the period of the war. From the standpoint of the refractories manufacturer this was unfortunate, as the conditions prevailing in the industry at that time prevented him from giving the electric furnace the attention it deserved. Not only were the sources of some of the best raw materials cut off, but added to the great problem of supplying an ever-increasing demand in all metallurgical and chemical lines were many new ones presented by nearly all users of refractories. It was not surprising, therefore, that the electric furnace received what must have appeared to be scant attention.

In discussing the subject of refractories it will be well to bear in mind that electric furnace design has been entirely in the hands of electrical engineers. Furnaces have been designed, built and sold before the refractories engineer has even had an opportunity to see whether satisfactory linings and roofs could be made up or not. In some cases conditions imposed by the designer were impossible, but under the conditions there was no other course but to make the best of a bad job. It must be remembered too that not only was the refractories manufacturer called upon to supply satisfactory linings and roofs for the standard makes of furnaces, but during the war dozens of "home-made" furnaces were built and put into operation, each one of which presented its own problems.

RAW MATERIALS

The manufacturer of refractories is always limited by his raw materials, earths or minerals in nearly every case. It is therefore impossible to produce finished products having qualities that the raw materials do not possess. In other words, he is bound within comparatively narrow limits.

So far as electric furnace refractories are concerned, the following materials are available:

Basic: Magnesite, dolomite, zirkite, alundum or carborundum, bauxite.

Neutral: Chromite, zircon, carbon, fireclay.

Acid: Silica.

MAGNESITE

Magnesite is a carbonate of magnesia and is found naturally in two forms: The amorphous or massive, and crystalline. The amorphous type is entirely unsuited for refractories purposes, but during the war, after the Austrian ore was cut off, this was the only material available, the source of supply being Cali-

fornia. The fact that the metallurgical industry was forced to use this unsuitable material accounts for much of the trouble encountered during the war period. In 1917 the crystalline magnesite from Washington began to come into use. This material is much like the Austrian, except that it is higher in lime and silica and lower in iron. In order to give it a bond it is necessary to add iron. This addition, together with the higher silica content, reduces its fusion point and basicity and lowers its efficiency considerably in comparison with the Austrian mineral. In recent months the Austrian ore has been gradually coming into the country in increasing amounts, but as yet has not reached a point where the supply nearly equals the demand.

There can be no question whatever that in electric furnace work the Austrian material is so superior as to be in a class by itself, and as soon as there is a sufficient quantity imported to supply the demand much of the electric furnace user's trouble with basic linings will disappear.

Magnesite is prepared for use by first dead-burning the crude ore, or driving off all of the CO_2. This is done in rotary kilns at a temperature of approximately 3,000 deg. F. When the material comes from the kiln it is sintered and in the form familiar to furnace men as dead-burned grains.

In manufacturing brick and shapes this dead-burned grain is ground and molded either in a heavy press or by hand. Undoubtedly the press-made product has very great advantages in electric furnace work on account of the great density obtained. When the product is well made and hard burned it will show practically no slag absorption. In cases where special shapes in small quantities or shapes impossible to make up on a mechanical press are required the hand-molding process is used. Magnesite is not suited to the manufacture of difficult or very large shapes, due to its tendency to crack or "squat" in the kiln at high temperatures. After coming from the molds the product is dried and burned in standard brick kilns and is then ready for shipment.

FUSED MAGNESIA

Fused magnesia has found use recently in the linings of induction furnaces. Little is yet known of its commercial value, but experiments would indicate that it may become extremely useful for certain purposes.

Calcined or dead-burned magnesite is fused electrically in manufacturing this product.

CHROMITE

None of the neutral refractories have come into wide use in electric furnace work.

Chromite, or more commonly "chrome," as the sesquioxide of chromium ($FeO.Cr_2O_3$) is called, is the best known of the neutrals. Since the Turkish, Grecian and

Rhodesian ores were cut off by the war, this country has had to depend upon the deposits of California and Oregon. Most of these deposits produced ores that ran only between 30 and 40 per cent Cr_2O_3 and contained a combination of other elements which gave them an extremely low melting point. The failure of brick made from domestic ores to stand up has caused the gradual discontinuance of their use. At the present time the foreign ores are coming on the market and a much better product, in fact one equal to or better than the pre-war product, is being manufactured.

ZIRCON

Zircon is here classed as a neutral, although it is questionable whether or not it should be considered as in the acid class. Its use is still in the experimental stage, but the few refractories that have been produced have been turned out by the same processes as used for magnesite.

Zircon does not have so high a melting point as zirkite, but it does not produce the carbide under reducing conditions in the presence of carbon. It is questionable whether it will ever come into general use.

CARBON

Carbon is used as a lining for special purposes, such as in the production of ferromanganese. The amorphous carbon is mixed with the binder, such as tar, and molded into shapes in presses or by hand and then burned in standard kilns. Very naturally the use of carbon refractories will be limited.

DOLOMITE

Dolomite is a carbonate of lime and magnesia. Before using it is usually dead-burned in rotary kilns and when properly prepared is mixed with a small percentage of iron, which aids its bond. Because of its high lime content it is unstable and will slake into powder upon exposure to damp atmosphere. Thus it is impossible to make dolomite brick and this refractory is, therefore, used only for patching bottoms.

ZIRKITE

Zirkite is a carbonate of zirconium. Zirkite brick and shapes are made by the same process as that used in the manufacture of magnesite brick. While zirkite is classed as a base, the ore has usually been so high in silica as to give it a neutral or acid reaction. It has not as yet come into wide use as a refractory and may be said to be still in the experimental stage. It is rather questionable whether this refractory will ever come into wide use on account of its affinity for carbon at high temperatures. Under such conditions it forms a carbide which has a low melting point.

CARBORUNDUM AND ALUNDUM

Carborundum and alundum would undoubtedly become very popular as electric furnace refractories were it not for their high cost. They have a very high melting point and low coefficient of expansion. Heretofore their use has practically been limited to jamb tile and roof brick. In jambs they have been quite successfully used.

BAUXITE

Bauxite has been little used for electric furnace work, due principally to its general failure in metallurgical work. Some other high-alumina refractories have found a little favor in cases where furnaces were turning out special products, but none of this class have been able to replace magnesite in basic practice.

Products made from these materials are usually hand molded, dried and burned in the ordinary manner.

FIRECLAY

Fireclay is the most widely used of all refractory raw materials and naturally refractories made from it find their greatest use in the metallurgical field. Fireclay products have not, however, become popular in electric furnace work, due principally to the high temperatures encountered. While there is little difference between the melting points of high-grade fireclays and ganister, the fireclays begin to soften considerably below their melting point and as a rule have a high slag and metal absorption.

Fireclays or clays used for refractories purposes are found in almost every state in the Union.

The methods of manufacture vary with the type of clays and their proposed use; fireclay brick are made by the auger machine, dry press, soft mud machine, and hand methods. They are dried and burned in ordinary brick driers and kilns.

SILICA

Silica or ganister rock is used for the manufacture of the well-known silica or acid refractories. Deposits containing the proper silica content and having the required physical properties are located principally in Pennsylvania, Wisconsin, Alabama, Montana, Colorado and Utah. The rock from Wisconsin and Pennsylvania has been used almost altogether in electric furnace refractories and of the two the Wisconsin rock seems to give the best results, especially in roof work.

Silica refractories are made by the hand process and dried and burned by ordinary methods.

RECOMMENDED REFRACTORIES FOR ELECTRIC FURNACES

The selection of the proper refractories for electric furnace work depends on several factors:

(1) The product of the furnace.
(2) Whether basic or acid process.
(3) The type of furnace.
(4) Whether furnace is operated continuously or intermittently.

In considering the first of these factors—the product of the furnace—it will be well to take up first the hearth and lining recommended for various products.

Steel Ingots and Castings.—Magnesite when high-grade steels are required. Silica when there are no special requirements on steel or when selected pure scrap is used.

Alloy Steels.—Magnesite exclusively.

Ferromanganese.—Magnesite or carbon.

Ferrochrome.—Magnesite or chrome.

Ferrosilicon.—Silica.

Cast Iron.—Fireclay brick when low temperatures are used and cupola practice simulated. Silica when high temperatures are used in rapid melting. Magnesite on irons of special low sulphur and phosphorus requirements.

Copper.—Magnesite on bronze scrap or pig containing lead. Silica or magnesite on refined pig (over 99 per cent Cu) and pure scrap.

Bearing Metal (Copper, Lead, Tin, Antimony).—Magnesite, as low as possible in SiO_2, especially with high lead content.

Monel Metal (Copper, Lead, Zinc, Tin).—Magnesite preferably, but silica can be used.

Bronze (Copper, Zinc, Tin).—Silica preferable, but manganesite can be used, where zinc is not too high.

Lead.—Magnesite exclusively.

Silver.—Silica.

Aluminum and Alloys.—Magnesite exclusively.

The recommendations are based upon the best practice of this country and Europe. There are naturally some cases where other linings would give better service, as the conditions in different furnaces can be so easily varied.

Refractories for Steel Furnaces

In the steel foundry the selection of the lining is, of course, limited to either silica or magnesite, depending upon whether the acid or basic process is used. This applies also to any other metal or metals.

The refractories used can be varied to suit the type of furnace only in a very limited way. In the bottom contact furnace, for instance, a metal cased magnesite brick has been tried out to a very considerable extent. The idea was that the metallic casings would aid the current flow from the charge to the contact bars on the shell. So far as it went the idea was good, but as the cases were filled only with dried dead-burned magnesite and not reburned there was little or no resistance to the molten metal penetrating to the shell. Far better results can be obtained by using burned brick and inserting between them thin metal sheets or strips.

In some types of furnaces a hot spot is developed on one section of the wall due to the location of the electrodes. In such cases, when a magnesite lining is used, a section will sometimes fall out when the furnace is tilted. This trouble can often be overcome by inserting a patch of silica brick in the hot section.

The continuous or intermittent operation of a furnace has a very important bearing on the refractories. This is especially true of the roof, which will be discussed later, but also applies to a lesser extent to the hearth and lining.

Silica and magnesite are both affected by rapid changes of temperature, but the latter to a much greater extent. In a basic operation it is, therefore, unwise to carry magnesite above the slag line, as the spalling action on silica will be much less.

When a furnace is operated intermittently, especially with prolonged shut-downs, the use of dolomite in any great thickness is unwise because it will slake to a powder upon exposure to the atmosphere.

Roof Brick and Its Laying

In the matter of roofs the furnace man is practically limited to the use of two refractories—silica and fireclay.

A roof properly built of high-grade silica refractories will undoubtedly give longer life than any other provided the furnace is operated continuously, but nothing will prevent spalling and short service when the furnace is operated intermittently. This latter fact has been extremely hard to impress upon the furnace users, with the result that the refractories manufacturer has been blamed for many roof failures for which he was not responsible. It is extremely hard to heat up an electric furnace slowly and avoid spalling the silica brick, and it is therefore necessary to determine by experiment whether a fireclay roof will serve better under the conditions. It is simply a question of whether the fireclay will melt or the silica spall faster, a matter easily determined by a comparison of the number of heats.

Most of the roof spalling that has been encountered in furnaces that have been operated continuously has not been due to temperature changes but to faulty construction. When a roof is laid up, either of shapes or 9 in., the proper expansion joints are usually left. On the first heat the wood expansion strips are burned out and the top is then thoroughly grouted with silica cement. This grouting fills all open joints and when the roof cools down the brick or shapes settle down into a fairly tight job. The expansion joints have practically disappeared, either through the settling together of the brick or by being filled with grout, and therefore upon the next heat the brick, having no chance to expand, begin to crush one another, the natural result being that the lower or small end is crushed off first and drops into the bath. This crushing or spalling does not take place over the entire roof but only between the skewback and electrode rings. It is in this area that the greatest thrust is encountered. Many efforts have been made to devise a means of overcoming this difficulty, but the only one that has met with success is the Griffin patent. This patent covers a roof containing special shaped brick in the rings between the skew and the electrode rings. Each of these brick has an offset or shoulder near the upper or top side which in practice prevents the grout from penetrating beyond it, thus leaving the original expansion joint free to come and go at the bottom.

In practice this roof is giving splendid results, the life under continuous operation being from 100 to 200 per cent greater than for straight brick.

There is no part of the furnace that receives harder treatment than the roof and no part that presents greater difficulties for fair comparisons. The difference of only a few inches in the distance from slag line to roof will make a very great difference in the life. One instance was noted where a Heroult roof ring was raised 6 in., with the result that the silica roof gave twice the number of heats.

The handling of the arc also has a very considerable bearing on the roof life.

Another very important cause of short roof life has been the lightness or instability of the roof ring. Sometimes this ring has been constructed of such light material that when a roof was picked up to be placed on the furnace the weaving effect was great enough to loosen all of the brickwork, the result being that some of the brick or shapes would drop out entirely, or at least drop down out of place, with the loss of a number of the important expansion strips. Many lining and roof failures blamed upon the refractories have been entirely due to the lack of rigidity in furnace construction.

Treatment of Refractories

All refractories are injured by exposure to the weather. The manufacturer uses every care to prevent his product from being exposed, only to note that many users pay no attention to this important point. Freezing is very injurious to any refractory, but is probably most damaging to silica brick on account of its porosity. Dampness in itself will not greatly injure a refractory, but the damage is done in using wet brick in a lining and then not taking sufficient time to thoroughly dry them out. There is absolutely no safe rule to follow in

the rate of heating a damp wall. It is a guess at best and the furnace man who uses wet brick should be willing to accept the results if his guess is wrong. Magnesite brick should never be wetted and should be laid up with dry cement. These brick give up moisture slowly, and if it is present and the heat is raised fast enough to convert it to steam, the brick will be disintegrated to a powder. At least 99 per cent of the complaints received by magnesite brick manufacturers on their product are due to the use of wet brick or the attempt to lay them up with a wet mortar.

Not enough attention is paid to proper expansion joints when using magnesite brick. A full ⅛ in. per ft., or 1½ per cent, should be allowed and it is always the best practice to allow for expansion between brick. This can easily be done by using pasteboard strips.

A special effort should be made to handle magnesite and chrome brick with extreme care, not only because of their high cost but because they are laid up with very small quantities of dry cement and chipped and broken edges and corners will not make a tight job. Brick should always be laid up with the cement recommended by the refractories manufacturer. Many patching cements and refractory mortars are extremely injurious to brickwork under certain conditions and none now on the market should be used in contact with magnesite brick.

The use of a course of chrome brick between the magnesite and silica has been common practice in metallurgical furnaces, but in the past few years has been found to be unnecessary. The presence of chrome is naturally objectionable when making many steels.

Finally, skill in furnace operation has much to do with the life of the refractories in the furnace walls and roof. The most critical period of the heat is just before the arc is veiled by the froth from the slag. At this time the section of the lining nearest the electrodes is exposed to an intense heat. Close attention by the operator at such times will add many heats to the life of the lining.

Substitute Belting in Germany

By C. A. Heise

DURING the war, while Germany was cut off from the world's markets, the want of various raw materials formerly imported from abroad made itself increasingly felt and though, in spite of the blockade, supplies were flowing in from neutral countries they cannot be said to have relieved the situation to any feasible extent. The German industries were thus thrown upon their own resources and immediately set to work on the utilization of all kinds of substitute materials.

Leather for belting was one of the many materials which became scarce and for which the need for efficient substitutes made itself severely felt. Though the pre-war consumption of leather for belting amounted only to ½ per cent, and for packing, etc., to 1 per cent, it should be remembered that practically every available ounce of leather was commandeered by the government for munition and other war industries. The textile industry might have come to the rescue but for its own shortage of raw materials. The need for suitable substitutes having become pressing, extensive experiments with belting made of wood pulp products were carried out; belts built up of wire, with wooden or pasteboard members, similar in construction to a driving chain, were also subjected to extensive tests. Many patents were granted for paper belts reinforced by an interior wire netting, etc., and reports at hand tend to show that on the whole they gave satisfactory results, being particularly adapted for horizontal drive, though it would appear that for agricultural machinery they were less suitable.

Use Continued After the War

With the lifting of the blockade Germany was once more enabled to replenish her depleted stores of some foreign raw materials. The use of substitute belting, however, is being continued because of the depreciation of German currency, which has almost prohibited the purchase of leather abroad.

For decades to come Germany will, for purely economic reasons alone, have to reduce her consumption of imported materials to a minimum while developing her productive capacity to a maximum. The truth of this statement has already been acknowledged by her manufacturers, with the result that their engineers are beginning to pay special attention to the redesigning and reconstruction of machinery with a view to adapting substitute belt drives. The experience gained during the last few years makes rather interesting reading. The instructions given by substitute-belting manufacturers will doubtless be read with equal interest in America inasmuch as some of them apply equally to leather belting—especially when of poor or medium quality—the careless handling of which is a costly factor in the maintenance of otherwise well-managed shops.

Limitations in Its Use

The difficulties and obstacles encountered in the initial stages were due not only to the lack of experience but to the fact that all available data on belting as contained in engineering handbooks and catalogs were applied to leather belting and could be used only for substitute materials of similar quality. The educational value of up-to-date trade journals was perhaps never more apparent than at this initial stage. Substitute belting proved in all cases inferior in strength to leather and it was accordingly found necessary to increase the standard widths of pulleys. As to crowning of pulleys—a subject on which there was always a divergence of opinion among engineers—it was definitely established that excessive crowning proved rather disadvantageous. Low speeds were also condemned, it being suggested that a speed of less than 3 ft. per second should be avoided, and tests carried out with a view of furnishing data on pulley diameters showed that the efficiency of pulleys having a diameter of less than 8 in. was rather poor. Particular attention has to be paid to proper alignment of shafts and pulleys in order to insure steady and quiet running and avoid transversal movements of the belt. Flange pulleys should not be used, the tendency of the belt to rub against, or crowd upon, the flanges having injurious effects upon the belt. For a similar reason it is suggested that belt shifters should be provided with rollers. Sharp edges on belt shifters or cone and step pulleys should be rounded off, their knife-like action being liable to destroy the best material within a short time.

Berlin, Germany.

Efficient Hydraulic Laboratory Press

The 21-ton hydraulic testing press shown in Fig. 1 is capable of handling an unusually wide range of materials and is quick and convenient to operate.

The base is solid steel, into which the two forged-steel strain rods are screwed. These rods are supported at the top by a cast-iron yoke through which runs a long screw. The screw has square threads and is operated by a handwheel.

The platen slides on brass-bushed bearings on the strain rods. It has a rim around the edge and spout for catching and draining off any juices that may flow over the sides. The platen is cast with a 3½-in. ram which extends into the steel base and which serves the purpose of a hydraulic cylinder into which a ram works that is forced forward by means of a screw and hand-operating device as shown by the left-hand projection in Fig. 1.

To operate the press the material to be pressed is placed on the platen and the swiveled head on the screw is then screwed down tight against the material. The other screw shown on the lower left of the illustration is then operated, thereby bringing pressure to bear on the liquid that fills the cylinders and forces the main ram upward, thus compressing the material. When the pressure reaches 4,200 lb. per sq.in. as indicated by the gage a total force of twenty-one tons is exerted between the swivel head on the screw and the platen.

Various containers to accommodate different classes of materials are provided. These include two sizes of curb type containers each with steel plates drilled and grooved to facilitate drainage. These plates are used
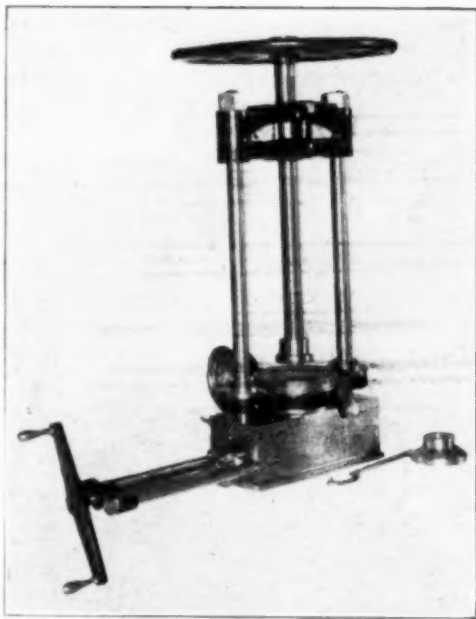
FIG. 1. HYDRAULIC LABORATORY PRESS

in pairs with the grooved faces together. Another type is the ring or Büchner container. This consists of a series of ten rings bolted together and so grooved and drilled that the expressed juices readily drain. A special plunger fits in the center of the rings on top of the material and the pressure is applied to this plunger. Solid test curb and test ring type containers are shown in Fig. 2. Still another type is the filter pot container which is highly satisfactory for use with substances that are in a liquid or semi-liquid state.

Clearance or daylight space of this press is 20 in.

from platen to swivel head when at its highest point. Inside measurement between rods is 9 in. The press is built by the Hydraulic Press Manufacturing Co. of Mount Gilead, Ohio.

An almost unlimited range of experimental work can be handled in this press, including extraction, filtering, briquetting, extruding and small forming and forcing jobs. In the latter uses a record of the pressure

FIG. 2. CONTAINERS FOR LABORATORY PRESS

required for any operation may be made, since the gage accurately shows the tonnage brought to bear on the material under pressure.

Such materials as flavoring extracts, tinctures from herbs, etc., are representative of the class of materials to which the extraction method would apply. Both the rack and cloth methods and curbs are used in this work.

For briquetting, dies may be arranged to press from one or both sides. Dies for extruding metal and other substances may also be used in this press.

Products that may be tested by the filtering process include dyes, clays, cocoa, oil extraction, etc. For the last, the containers are made very thick so that when heated they retain the heat during the period under pressure.

A Furnace for the Determination of Moisture in Dry CO_2-Free Air

By J. A. MONTGOMERY

In determining the percentage loss of moisture at 110 deg. C. it is usual in quantitative analysis to heat the material in question in an ordinary gas oven. Should the material which is being analyzed have any great tendency to hydrate and absorb CO_2, as in the case of portland cement, the loss obtained at 110 deg. C. will very likely be erroneous. The difficulty has been overcome in this laboratory by the use of a small electric furnace through which a stream of dry CO_2-free air is conducted. A cross-section of the furnace, which has been producing satisfactory results for the past three years, is shown in the accompanying diagram. It was designed by Dr. E. O. Harder.

It consists of an iron cylinder 6 in. in diameter and 8 in. long. One end of the cylinder is threaded, and a heavy iron cap, which forms the bottom of the furnace, is tightly screwed to it as shown in the illustration. The furnace is supported by four iron legs screwed into the bottom. The legs are of sufficient length to permit the connection of an air line with the inlet cock and also to provide space for the two electric terminals. Spark

plugs serve as electric terminals. The top or lid consists of an iron cap with a machined groove ½ in. deep and sufficiently wide to permit the walls of the furnace to extend up into the lid as indicated. This arrangement is employed to afford a more closely fitting cover. An iron well through the center of the lid and extending

Section A-A
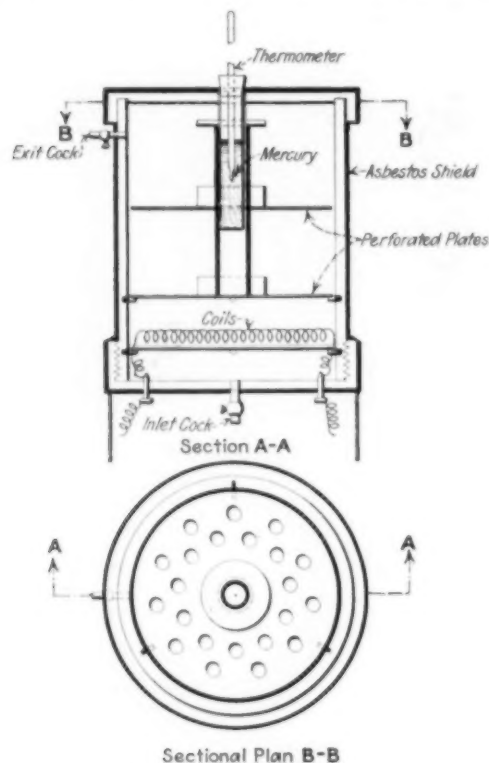
Sectional Plan B-B

down into the center of the furnace is half filled with mercury, which affords a bath for the thermometer. A suitable stand of two perforated plates (see sectional plan) with a capacity of sixteen porcelain crucibles rests upon four lugs which are screwed into the wall of the furnace. The plates are attached to each other by means of a central column. This is hollow in order to permit the mercury well to extend down within it. One outlet cock, which serves as an air exit, is provided in the upper portion of the furnace wall. The heating unit consists of 32 ft. of No. 17 nichrome wire in ten coils (these are embedded in fireclay) and secured to an asbestos board. The unit is heated by means of a 110-volt circuit, while external resistance is employed to control the temperature. Compressed air, which is passed through a train of towers containing sulphuric acid, soda-lime and calcium chloride to remove the H_2O and CO_2, enters the inlet cock at a moderate rate. This furnace is adapted for temperatures up to 250 deg. C. and can easily be controlled within five degrees. The entire furnace is covered with several coatings of heavy asbestos paper.

Structural Materials Research Laboratory.
Chicago, Ill.

Excess Temperature Cut-Out

To prevent the overheating and consequent burning out of heating windings in electric furnaces, a new device has been introduced and provisionally patented by the Automatic & Electric Furnaces, Ltd., the manufacturers of the Wild-Barfield Furnace described in CHEMICAL & METALLURGICAL ENGINEERING for Oct. 6, 1920, p. 699. This consists of a replaceable loop of low-resistance wire which enters the furnace for a short

distance connected in series with the heating current. So long as the loop is intact current will heat the furnace. Should, however, the temperature of the furnace, due to neglect, become excessive and so endanger the heating winding, the wire loop melts and interrupts the heating current and at the same time a red pilot lamp or other warning signal is put in operation. A loop having a melting point of 960 deg. C. has been found very useful in protecting furnaces wound with base-metal alloys.

Soda Ash Airveyor

The increasing difficulties in obtaining common labor to unload and handle bulk materials from cars and barges, together with the high cost of wages, are felt all over the country, and this is especially the case where powdery materials, such as cement, soda ash, powdered lime and material of similar nature have to be carried. The injurious effect of the dust makes laborers refuse the work.

The Guarantee Construction Co. of New York, pioneer in the field of building pneumatic conveyors, gave this question considerable thought and study, the result of which was the installation of a portable airveyor at the plant of the Federal Plate Glass Co. in Ottawa, Ill., to handle soda ash, salt cake and powdered lime from cars to bins in an adjacent storage house. Specially designed dust collectors for the purpose have proved very efficient, so that the disposition and loss of dust were overcome in a way entirely satisfactory.

The system used is a suction system, whereby the material is drawn from the car through a flexible hose into a vacuum tank designed to recover a large percentage of the dust floating in the air. This tank, together with a motor-driven positive rotary exhauster and another special dust collector of the double shell type connected to the exhaust line, is mounted on a movable platform running above the storage bins and
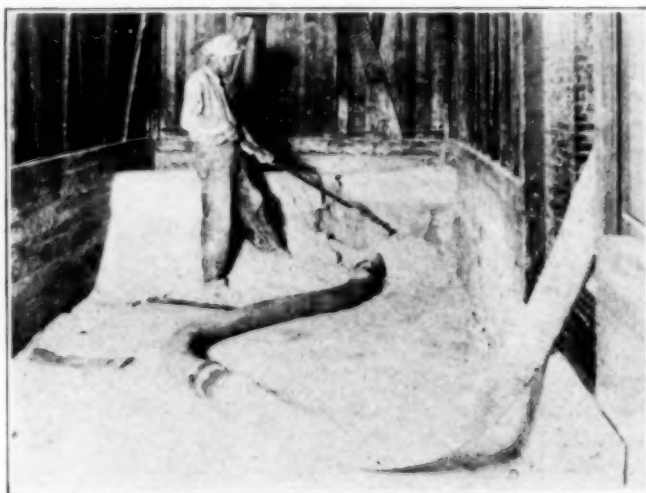
SODA ASH AIRVEYOR

delivers the material through a rotary airlock feeder directly to storage. The dust recovered in both tanks is collected separately and also delivered through rotary feeders to the bins, so that there is very little dust shown at the exhaust.

The airveyor has been in successful operation for about six months, and enables the purchaser to unload material with one man in the car, working under much more agreeable conditions. The inside of car, as well as the storage house, is entirely free from the

obnoxious dust, thus allowing other work to be done on the premises during unloading, which was impossible before.

The airveyor is handling material at the rate of ten tons per hour, and its capacity could have been greater if building conditions had not made it impossible to increase the size of apparatus. Airveyors can be built to handle quantities up to twenty tons per hour for movable units, while when stationary, a capacity of forty tons can be obtained without making the installation too costly and cumbersome.

Electric Arc-Furnace Regulator

High electrode operating speed and close precision of regulation with absolute freedom from hunting are the two important features of the electric arc-furnace regulator just placed upon the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Speeds 2½ to 3 ft. per min. depending upon the amount the quantity being regulated is from normal and 5 per cent precision are claimed.

The ability of this regulator to incorporate high speed with a narrow current zone is due to the fact that the electrode speed tapers all the way from full to zero as the regulated current approaches its normal value. In other words, within certain limits the restoring speed is approximately proportional to the amount the current in the electrode deviates from normal. This permits the greatest possible electrode speed for a given current variation. This feature is particularly appreciated during the melt-down of cold scrap. For small variations in current the speed is slow enough to prevent continuous breaking of the arc and at the same time, when the solid metal begins to cave into the pools of molten metal under the electrodes, sufficient speed is available to permit the regulator to extricate the electrode before the time relay allows

ELECTRIC ARC-FURNACE
REGULATOR

the breaker to trip. When the current is turned on a furnace charged with cold scrap, it is necessary only to throw the regulator control to the automatic position. Regardless of the position of the electrodes at this time, the regulator will allow each one to run down at full speed until it touches the steel, when complete automatic regulation will commence. It is absolutely impossible for an electrode to get into the steel, and practically no attention is required from the operating personnel.

One very important feature of the regulator is its utilization of the arc voltage as well as the arc current to control the motors. This device absolutely prevents the electrodes getting into the steel under automatic regulation. Under-voltage relay trips on the control circuits are unnecessary. With any purely current actuated device, it is impossible to maintain equal arc

lengths in furnaces using two or more electrodes, particularly when operating at reduced power. In the regulator, the arc voltage, as well as the electrode currents, is maintained balanced.

The voltage coils also make the control of each electrode independent of the others in the surface. In fact, one electrode may be entirely withdrawn without disturbing any of the others. In a regulator dependent upon current control exclusively, any movement of one of the electrodes causes the elements of all other electrodes to change their positions.

Synopsis of Recent Chemical & Metallurgical Literature

Coal-Saving in the Chemical Industry.—A detailed study of the sixty typical steam boiler installations in English chemical plants has been completed recently by DAVID BROWNLIE. The results are given in a series of articles in the *Chemical Trade Journal and Chemical Engineer* (Aug. 21, p. 247; Sept. 4, p. 311; Sept. 11, p. 343). Since these results form part of a comprehensive survey of steam generation methods in British industry as a whole, it is possible to compare the figures for the chemical industry with corresponding data for a group of installations representative of all industries.

The articles cover the methods used in making the tests, a tabulated summary of the results obtained at each of the sixty plants, a detailed discussion and analysis of this table, a summary of the results, and recommendations as to methods for promoting fuel economy in these plants. Since it is almost impossible to summarize adequately a paper of this character, the following excerpts serve merely as an indication of the scope of the article, and the reader is referred to the original for details.

Contrary to what might naturally be expected, the efficiency of steam generation in the chemical plants studied was found to be slightly below the average. In commenting on this, Mr. Brownlie added that he had been struck very forcibly by the lack of organizing and engineering ability displayed in many chemical works. As regards general factory organization and modern methods of costing, many industries such as the motor car trade are so far ahead of the methods generally used in the chemical trade that the comparison is painful. From the point of view of welfare of employees, canteens, lavatories, rest rooms, etc., the chocolate industry and many engineering concerns are in another world compared with most chemical works. As regards engineering, a trained engineer from a steel works, shipbuilding yard or almost any large engineering shop would be considerably staggered at the general engineering of the average chemical plant. Several interesting points will be noted in the detailed analysis of results.

Out of the sixty plants, in only two cases was the fuel analyzed in an accurate manner, so that the quality of the fuel was known. In certainly over 90 per cent of cases the fuel was used without the slightest knowledge of its heating value. As is, of course, well known to steam users today, the fuel supply is so complicated that the consumer is glad to get hold of any kind of coal and there appears to be no control over the quality.
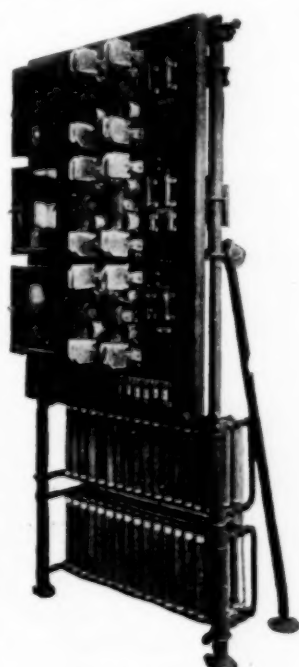
Before the war, however, steam users had a very extensive choice of coal, but in the chemical industry there were certainly not 10 per cent of steam users who analyzed the coal and purchased accordingly.

With regard to scale troubles, there were twenty-seven plants which either had no trouble at all or only slight trouble, twenty-one which might be described as "moderate" and twelve which can only be described as "chronic." It is rather astonishing to find that over 50 per cent of the boiler plants in the chemical industry are in trouble with the feed water, in spite of the fact that in most cases efficient chemists are employed in the plants. The general principle seems to be to leave the boiler plant to the engineering department, which has no time to attend to it, and the interference of the chemist seems to be resented. It is further astonishing to find how many chemical plants buy "quack" boiler compositions and pay exorbitant prices for them.

Of the sixty plants, fifty-five were not equipped with CO_2 recorders and only two plants can be described as fitted with CO_2 recorders in good working order and regularly used. The tests show that the average CO_2 obtained is only about 8.5 per cent. The figures can be divided as shown in Table I.

Only nineteen plants were fitted with superheaters. In these the average temperature of the steam was

TABLE I. PER CENT CO_2 IN FLUE GASES

Classification	60 Chemical Plants No. of Plants	Per Cent	250 Plants Typical of All Industries, Per Cent
Very good, over 12 per cent	4	6.7	1.6
Good, 10 to 12 per cent	14	23.3	6.8
Medium, 8 to 10 per cent	17	28.3	25.6
Poor, 5 to 8 per cent	22	36.7	57.6
Very bad, under 5 per cent	3	5.0	8.4
Total	60	100.0	100.0

340 deg. F. before superheating and 450 deg. F. after—that is, 110 deg. F. superheat. The value of superheating seems to be very little realized. Superheating can be of two kinds. First of all, there is the question of partial superheating (say, 75 to 100 deg. F.), with the idea of completely drying the steam so as to avoid condensation losses in the pipes. Most chemical works have an extensive system of steam pipes, and partial superheating is of particular value in such cases. High superheating (200 deg. F.) is used to increase the efficiency of the steam utilization plant.

The true average net working efficiency for the whole sixty plants was found to be approximately 58 per cent —that is to say, 42 lb. out of every 100 lb. of coal fired

TABLE II. EFFICIENCIES OF BOILER PLANTS

Classification	60 Chemical Plants No. of Plants	Per Cent	250 Plants Typical of All Industries, Per Cent
Over 80 per cent	0	0	0.8
75 to 80 per cent	4	6.7	3.6
70 to 75 per cent	3	5.0	5.2
65 to 70 per cent	12	20.0	12.0
60 to 65 per cent	9	15.0	17.6
55 to 60 per cent	13	21.6	24.8
50 to 55 per cent	9	15.0	18.8
Less than 50 per cent	10	16.7	17.2
Total	60	100.0	100.0

is wasted. The average is slightly worse than that for all industries (60 per cent). The efficiencies are divided as shown in Table II.

It will be noted that 53.3 per cent of the plants are working with an efficiency of less than 60 per cent and only 11.7 per cent of the plants exceed 70 per cent.

The general conditions of steam generation seem to be much the same all over the world and the average efficiency of boiler plants is probably less than 60 per cent. In the United States the general performance was found to be very poor on investigation by the Fuel Economy Department and opportunities for substantial economies were glaringly evident. An examination by the author of thirty or forty boiler plants in France has shown that although water-tube boilers are in more extensive use and fuel is more expensive and difficult to obtain, it is very doubtful whether the results obtained are any better than in England.

If a boiler plant is considered as a factory in itself, the methods necessary for scientific control are easily vizualized. The raw materials are essentially coal, labor, water and air, and the finished product is steam at a given temperature and pressure. Hence, in order to keep an efficient production record, it is necessary to have continuous data on the amount of water evaporated, the amount of steam used in the various processes or departments, the amount of coal burned, the calorific value of the coal and the percentage of CO_2 in the flue gases.

A typical boiler plant of six Lancashire boilers burns 12,000 tons of coal a year, valued at, say, £24,000. The cost of a complete set of instruments, including water meters, automatic coal weighers, CO_2 recorder, coal-testing outfit, pyrometer installation, recording draft- and steam-gages, is less than £1,000. Taking the cost of a skilled attendant at £350 a year, interest at 6 per cent and depreciation at 15 per cent, the total annual expenditure will be about £600. The saving due to efficient control is, on a most conservative estimate, 10 per cent, or £2,400 a year.

Recent Chemical & Metallurgical Patents

British Patents

Extracting Metals. — Ores, concentrates, furnace dust and the like, preferably finely divided, are mixed with sodium chloride, preferably in finely divided form or in solution, and the mixture is heated to the volatilization temperature of sodium chloride, whereupon metals are volatilized and may be collected. The process is applicable, for example, to the treatment of lead-zinc ores, lead and silver being volatilized, and to the extraction of other metals such as copper, bismuth and molybdenum. (Br. Pat. 144,728—1919. KRUPP AKT. GES. FÜR GRUSONWERK, Buckau, Germany, Aug. 11, 1920.)

Frosted Glass.—Relates to a process for producing a mat surface on glass. According to the invention, the glass surface is coated with a composition containing a substance which, when heated, reacts on the glass to form an acid-decomposable product. The composition also contains a relatively inert substance and a binding agent. The coated surface is heated to the required extent and, after cooling, the acid-decomposable matter is removed by an acid other than hydrofluoric. As an example, a composition consisting of basic lead silicate

pulverized porcelain and a binder such as gum is described. (Br. Pat. 144,737—1919. T. UEDA, Kyoto, Japan, Aug. 11, 1920.)

Electric Endosmose.—Before separation by electric endosmose of mixtures of colloids, ions and non-ionized bodies, ions which are unsuitable for the process are replaced by more suitable ones—for instance, chloride, sulphate, or phosphate ions by inorganic or organic ions of the same or different valency, or calcium, magnesium or aluminum by ammonium, sodium, or potassium. If a mixture containing ammonium sulphate and albumin is treated in a three-compartment cell, even the most electro-positive diaphragms do not prevent more rapid migration of the ammonium ions and consequent acidity of the mixture in the middle compartment; but after treatment of the mixture with barium acetate and removal of barium sulphate, the mixture on electrolysis with a positive diaphragm at the anode remains feebly alkaline and albumin is not precipitated. If barium chloride is similarly used, the mixture keeps feebly acid. Both anions and cathions can be replaced; for instance, if aluminum sulphate is present, the aluminum can be replaced by ammonium and the sulphate ion by a monovalent one. (Br. Pat. 144,710—1919. ELEKTRO-OSMOSE AKT. GES., Berlin, Aug. 11, 1920.)

Organic Metallic Compounds, Arsine Derivatives.— Amides and acids of the general formulæ $R_2AsCONH_2$ and $R_2AsCOOH$, when R = a fatty or aromatic radical, are prepared by hydrolysis of the corresponding nitriles R_2AsCN. According to examples, dimethylarsinoformic acid and diphenylarsinoformic acid are obtained by treating cacodyl nitrile and diphenylarsine nitrile with dilute sulphuric acid; diphenylarsine nitrile is converted into the corresponding amide by hydrogen peroxide, and the amide converted into diphenylarsinoformic acid by sodium nitrite and sulphuric acid. Dimethylarsinoformic acid forms salts with sodium, calcium, magnesium, manganese, iron, cerium, mercury, quinine, strychnine, etc. (Br. Pat. 144,806—1919. A. JOB and H. GUINOT, Paris, Aug. 18, 1920.)

Lecithin.—Lecithin is separated from animal or vegetable matter containing it, or from crude lecithin, by dissolving the raw material—e.g., egg yolk or fish roe—in an organic solvent, treating the solution with hydrogen in the presence of a hydrogenating catalyst such as palladium or nickel, interrupting the hydrogenation when the lecithin has been saturated, as shown by test extraction with cold ethyl acetate, then evaporating off the solvent, and dissolving the residue in hot ethyl acetate, from which, on cooling, the lecithin separates out. (Br. Pat. 144,895—1919. C. BAUMANN and J. GROSSFELD, Recklinghausen, Aug. 18, 1920.)

Cuprammonia Cellulose Solutions; Artificial Threads.—Solutions of cuprammonia cellulose, which are permanent and capable of being satisfactorily spun, are obtained by the addition of sugars both of the grape-sugar group and of the cane-sugar group; the former are added to prevent oxidation of the cupric salt and of the cellulose, and an amount of 0.25 per cent of the cellulose taken is sufficient; the sugars of the cane sugar group and of which refined beet sugar is the most suitable, are added to effect or maintain the hydration of the cellulose, and of these sugars it is sufficient to add 2 per cent of the weight of cellulose taken, or a little more if the cellulose has not been decomposed. By the addition of a reducing sugar, it is stated that the solubility of cupric oxide in ammonia is increased, and the

solution of the cellulose in such solution rendered more rapid and complete. (Br. Pat. 145,035—1919. GLANZ-FARBEN AKT. GES., Petersdorf, Germany, Aug. 18, 1920.)

Dental Cements.—Colloidal silicic acid in the form of hydrogel, acetogel or alcogel, is added to dental cements of the kind in which a phosphoric acid or acid phosphate is an ingredient to prevent the liberation of acid after the cement has set. The silicic acid may be added to the powder before it is mixed with the phosphoric acid, or the powder may be mixed with a solution of the silicic acid in phosphoric acid or an acid phosphate. In an example, to a solution of magnesium and aluminum sulphates in molecular proportions is added sodium silicate and caustic soda lye until the magnesium aluminum silicate is precipicated. Colloidal silicic acid is added and the precipitate is filtered, dried and mixed with phosphoric acid and an acid phosphate. (Br. Pat. 145,052—1919. S. SCHIFF, Karlsruhe, Aug. 18, 1920.)

Preparation of Urea.—Urea is prepared by forcing a mixture of carbon dioxide and ammonia into an autoclave and maintaining the melt formed for a sufficient time at the temperature required for the transformation of ammonium carbamate into urea. The process may be carried out in a continuous manner by forcing the gases into an autoclave and keeping the melt at 135 deg. C. for two hours, then slowly releasing the reaction mass through a bottom valve to a column still in which it is distilled, urea solution running off from the bottom of the still while unchanged ammonia and carbon dioxide pass off to a dephlegmator and thence back to the compressor. More ammonia and carbon dioxide are supplied to the autoclave, or an aqueous solution of ammonium carbamate or carbonate is supplied to the top of the column still. The amount of moisture in the gases led back to the compressor may be controlled by keeping the temperature at the outlet of the dephlegmator at say 60 deg. C. The expansion of the melt may be allowed to take place in two stages to save compression energy. (Br. Pat. 145,060—1919. BADISCHE ANILIN UND SODA-FABRIK, Ludwigshafen-on-Rhine, Aug. 18, 1920.)

Separating Suspended Impurities From Gases.—In the electrical separation of impurities suspended in gases, there is employed an undamped pulsating unidirectional voltage having a frequency considerably higher than about 50—the frequency ordinarily employed with alternating current—and preferably having a medium frequency of the order of 250-1,500 periods; a frequency of 500 is particularly advantageous. It is stated that such a pulsating voltage may be super-imposed on "a constant direct-current voltage pulsating with low frequency." (Br. Pat. 145,477—1919. METALLBANK UND METALLURGISCHE GES., Frankfurt-on-Main, and J. E. LILIENFELD, Leipzig, Sept. 1, 1920.)

Deodorizing Soap.—Liquid soap is deodorized by treating it under pressure—e.g., in an autoclave at a temperature above 100 deg. C. with steam. The autoclave may be heated by direct firing or by admission of superheated steam. Hot water or steam, as the case may be, is admitted so as to keep the concentration of the soap solution approximately the same during the operation. After some hours a valve in the autoclave is opened, and odoriferous impurities are carried off by the escaping steam. (Br. Pat. 145,502—1919. PERSAPOL GES., Hanover, Germany, Sept. 1, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Conservation of Timber by Chemical Treatment

On Friday evening, Nov. 5, the American Section of the Society of Chemical Industry met at the Chemists' Club for a conference on conservation of timber by chemical treatment. Sumner R. Church presided. Herman von Schrenk spoke on the preservative treatment of wood and forest resource conservation. About 65,-000,000 gal. of creosote oil is used annually at present. The supply can be increased greatly if the practice of burning the crude coal tar at the coke and steel plants ceases. About 43,000,000 lb. of zinc chloride, the second most important preservative, was consumed last year and ample supplies are available to meet any demand. Mercury and fluoride salts are exceptionally good for these purposes, but comparatively are too costly. Interesting and instructive slides were displayed showing graphically the amount of timber available, and the excess of consumption over production. Mr. von Schrenk drew conclusions showing how preserving would assist in overcoming this discrepancy between consumption and production.

Mr. Kuehn spoke on the outlay and operation of a modern wood preserving plant. He discussed very fully the methods of treating wood in the preserving plants. There are in the United States 132 such plants. The output of these plants has been only 160,000,000 cu.ft. of wood, a very small percentage of the wood utilized. Mr. Kuehn said that the development of the industry was being held back by the shortage of coal tar and other preserving chemicals. He discussed fully the most approved methods of handling the wood and piling it in the storage yards. He called attention to the necessity for proper seasoning of the material before treatment and he also gave a thorough explanation of the methods of treatment, calling particular attention to the difficulties encountered and the means by which they were overcome. His talk was fully illustrated with slides showing the various processes in actual operation.

At the close of the meeting a buffet lunch was served in the rooms of the Chemists' Club. About two hundred members and guests of the society were present at the session. Suggestions for topics for forthcoming meetings were asked by the directors, who are making every effort to make the sessions both interesting and instructive to the members.

Consulting Chemists Named for C.W.S.

To form the nucleus for his consulting staff General Amos A. Fries, the Chief of the Chemical Warfare Service, has designated each member of his advisory committee a consulting chemist of the bureau. The chemists thus designated are W. D. Bancroft, R. C. Tolman, A. B. Lamb, E. P. Kohler, F. M. Dorsey, W. K. Lewis, L. T. Sutherland, L. C. Jones, C. L. Reese, William H. Walker, Bradley Dewey, Reid Hunt, A. S. Loevenhart and Julius Stieglitz.

The advisory committee has been asked by General Fries to designate other chemists who may be induced to assist the bureau in a consulting capacity.

Composition of Automobile Exhaust Gases

A. C. Fieldner, speaking before the Chemical Society of Washington on Oct. 28, reported an extensive series of investigations made by the Bureau of Mines on the composition of automobile gases in relation to ventilation of vehicular tunnels. This work has demonstrated a number of important conclusions as to the extent of incomplete combustion in automobile engines. An average of about 6.4 per cent carbon monoxide in the exhaust gases from all types of machines tested for all conditions of test is reported. With the proposed vehicle tunnel from Manhattan to New Jersey this represents at the full capacity of the tunnel a discharge of about 400 cu.ft. of carbon monoxide per minute, which would require for proper elimination the movement of approximately 1,000,000 cu.ft. of air per minute.

The percentage of carbon monoxide in the exhaust varies widely with the adjustment of the carburetor and the conditions of driving. The largest percentages of carbon monoxide are formed when accelerating or climbing grades—that is, at the time of greatest power demand. The point of maximum power production from an engine is quite different from the point of maximum thermal efficiency. At the point of maximum power richer mixture is used than corresponds either to the point of maximum thermal efficiency or to the point of theoretical air-gasoline ratio. As a practical matter, the best remedy for gasoline losses caused by inefficient operation is, in the opinion of Dr. Fieldner, to be accomplished only through more extensive use of dash control devices so that the richness of the mixture can be adjusted by the driver according to the power demands.

To Get More Data on Gas Wounds

In order that all available information on gas casualties in the American Expeditionary Forces may be compiled, the Surgeon General of the Army is having all information with regard to such casualties segregated from the records. One of the significant developments of the war is the fact that gas caused a large percentage of the casualties, comparatively few of which resulted fatally. It is claimed that no single case of tuberculosis can be traced directly to injury from gas. One of the the objects of the present inquiry is to verify this assertion.

New Haven Section of A.C.S. and Bridgeport Chapter of A.S.M.E. Hold Joint Meeting

The New Haven Section of the A.C.S. and the Bridgeport Chapter of the A.S.M.E. held a joint meeting at the Seaside Club in Bridgeport, Friday evening, Oct. 19, 1920.

John R. McGregor of the Eagle-Picher Lead Co. gave a very interesting and instructive lecture, illustrated by moving pictures, on the prospecting, mining and smelting of lead ore and the manufacture of lead products from pig lead, which was enjoyed by all present.

Future of International Catalog of Scientific Literature Considered at London Conference

An international conference of delegates from important scientific academies to consider the future of the International Catalog of Scientific Literature has just been held in London at the invitation of the Royal Society. Representatives were present from fourteen countries. The American delegates were Dr. R. M. Yerkes, Prof. L. E. Dickson, Prof. L. P. Eisenhart, G. C. Gunnell and Dr. S. I. Franz, representing the National Academy of Sciences, the National Research Council and the Smithsonian Institution.

Up to the time of the war, more than thirty countries were joined in undertaking the indexing and publishing the index of the scientific literature of the world. Fourteen annual issues, each of seventeen volumes, have been published covering the literature from 1901 to 1914. The results of the war, together with the much increased cost of printing and publishing, have interrupted the undertaking and no index of scientific literature published since 1914 has been issued. The conference decided that even though a change may be made in the future in the method of indexing and of publishing the index, as has often been suggested, it is imperatively necessary to continue the present method until the scientific literature published up to the end of 1915 and possibly also that up to the end of 1920 has been catalogued.

Business Conditions of Ohio Chemical Industries

In a majority of the industries of Ohio production is at a low ebb. Manufacturers feel that they are facing a period of readjustment and a move toward lower price levels. There is no feeling of pessimism in the reports emanating from the various centers—in fact, operators feel confident of a stimulated demand with a return to a more normal basis.

In the Akron district the production of tires and other rubber products is at its lowest point and manufacturers are taking advantage of the situation to conduct inventories. On Nov. 1 the Goodyear Tire & Rubber Co. resumed operations on a four-day weekly basis with daily production at about 6,000 tires. The Firestone factories are operating on a five-day weekly basis. The outlook for the tire industry is not of the best. Most of the larger companies are operating on a 20 to 25 per cent of normal production basis.

Annual inventories showed that the larger companies were hard hit by high prices on raw material. Accustomed to buying in the open market in large quantities, they are reported to have large stocks of raw rubber and cotton which were purchased at the peak of high prices. Now that prices on both have dropped considerably, it is only the smaller companies that can take advantage of present prices, having bought on a closer margin.

On the other hand the paper mills of the Miami Valley district report much better conditions. During the past few weeks they have been able to maintain maximum production through firmer supplies of pulp and fuel. Few of them, however, have a reserve supply, but no curtailment is expected because of shortage of raw material in the immediate future.

The Champion Coated Paper Co. has let contracts for a new building 720 x 55 ft. to house the sizing and bleaching departments and to provide additional clay storage space. Work will be started about Dec. 1.

Iron and steel operators in the Youngstown district report slightly reduced production. The inflow of new business is not up to the rate of shipments, which means, of course, slowing up of operations unless buying revives shortly. There is a general feeling in this district that the industry will encounter readjustments and move toward a lower price level before the big overhanging demand for steel makes itself fully felt. There is no evident indication to be pessimistic over the outlook, but rather a feeling of relief among the leading producers that a return to more normal conditions is in sight. Opinion among local bankers and business men is that the district is in an exceptionally comfortable position for any readjustments that may come.

The fuel situation is acute in the East Liverpool pottery district. Most of the potteries are from six months to a year behind in production and no promises are being made for future deliveries. The transportation situation is especially acute and little coal is being received. Because of gas shortage many of the potteries are substituting fuel oil for kiln firing as the most feasible solution of the fuel problem.

Bureau of Mines to Push Co-operative Work

During the next few months L. I. Shaw, the Assistant Chief Chemist of the Bureau of Mines, will be attached to the Columbus Experiment Station of the bureau to conduct intensive work looking to the formation of co-operative agreements with ceramic industries.

The Bureau of Mines now has in effect with state institutions and private companies co-operative agreements which make available more than half a million dollars annually as a supplement to the Congressional appropriations allowed the bureau. One of the conditions of these co-operative agreements is that the results of these experiments are to be made public so that the entire industry may have the benefit of the work. Due to the success which has attended this form of activity on the part of the bureau it is expected that considerable expansion of this activity will take place in the future.

General Staff May Be Ousted

One of the probable effects of the change in the national administration will be the appointment of a new Chief of the General Staff of the Army. The present Chief of Staff opposed the continuance of Chemical Warfare Service and is believed to regard the development of military gases as a matter of small importance. Despite the very decided manner in which Congress overruled the recommendation of the General Staff in regard to chemical warfare there are evidences that the new service has not been accorded the same sympathetic consideration as have certain of the older branches. There is a feeling among chemists that the Chemical Warfare Service will fare much better under nearly any officer likely to be appointed Chief of Staff.

Portland a Distributing Center for Sulphur

Portland, Ore., is gaining increasing prominence as a distributing point for sulphur. Shipments totaling about 10,000 tons of this mineral have recently been landed at Portland by steamers from Galveston and Sabine, Tex. Much of the sulphur is used by the paper mills in the neighboring towns of Oregon City and West Lynn, Ore., and Camas, Wash.

Imports and Exports of Chemicals

Heavy increases in chemical imports took place in September as indicated by the figures which just have been assembled by the Bureau of Foreign and Domestic Commerce. The imports of chemicals on the free list are at a rate double that of last year, as shown by the figures for the first nine months of 1920. During September of 1920 the importations of duty free chemicals aggregated $13,229,907. This compares with $7,054,012 in September of 1919. The imports of dutiable chemicals decreased in September of this year as compared with the corresponding month of last year.

Fertilizers during the first nine months of the current year are being imported at about eight times the rate of importation during the corresponding period of last year. During September, just past, fertilizers to the value of $4,195,848 were imported. In September of 1919 the value of the imports was $890,097. Imports of coal-tar products increased from $512,004 in September, 1919, to $870,057 in September, 1920. Potash imports in September, 1919, were valued at $25,200. This year in September $445,083 worth was imported. Comparative figures as to the importation of certain chemicals which come in in smaller volume, are as follows:

	September 1919	1920
Ammonia, muriate of	$40,395	$38,930
Arsenic, sulphide of	36,043	33,813
Glycerine, crude	50,882	160,866
Iodine	2,275	7,972

Exports of chemicals in 1920 ran a million dollars higher than they did in September of 1919. Acid exports increased from $425,160 in September of 1919 to $483,043 in September, 1920. Dye exports increased from $1,425,983 in September, 1919, to $3,119,295 in September of 1920. Our exports of dyestuffs to China have tripled. The United Kingdom is buying much more heavily in the American dye market. Mexico's increased buying power is reflected in its greater purchases of American dyes. India and nearly all the South American countries took American dyes during September. The total soda exports in September of 1919 were valued at $1,845,715. The exports in September of this year were valued at $2,131,347. Some of the chemicals exported in lesser amounts are as follows:

	September 1919	1920
Formaldehyde	$155,833	$302,150
Chlorate of potash	36,407	28,229
Chloride of lime	47,636	180,719
Sulphur	763,346	700,841
Petroleum jelly	213,806	205,281

World Trade Club Formed in St. Louis

The recent organization of the World Trade Club of St. Louis, with over 100 members, by the Foreign-Trade Bureau of the Chamber of Commerce, the local representative of the United States Bureau of Foreign and Domestic Commerce and export managers representing the largest exporting industries is another indication of the interest being taken in foreign trade by manufacturers located in the interior cities.

The object of the club will be the promotion of foreign-trade interests of the city of St. Louis and the Mississippi Valley. It will work along the same line as the Export Managers' Club of New York, the Exporters' Round Table of Boston and the foreign-trade clubs of Chicago and San Francisco. Regular meetings will be held in the form of a round-table discussion in order that export managers may have an opportunity to discuss their problems and secure practical advice and assistance from members who have had experience along similar lines. From time to time authorities on certain phases of export trade will be brought to St. Louis to give the local men the benefit of their studies and experience.

The largest exporting firms and the various foreign-trade promotive agencies are represented on the executive committee in order to co-ordinate in one organization all industries and associations active in foreign trade. The officers of the club are: President, F. Ernest Cramer; vice presidents, R. P. Block, W. E. Tarlton and A. H. Boette; secretary and treasurer, J. A. Troy.

New Motor Fuel in South Africa

In addition to natalite, which is manufactured in Natal from the refuse of the sugar-cane mills and used extensively in propelling motor cars in South Africa, there has recently been produced another motor fuel to meet the shortage and high cost of gasoline in that country, reports Vice-Consul Pisar of Cape Town. The basis of this new fuel, which is called "acetol," is alcohol and ether, which comprises 90 per cent. The other ingredients are treated as a secret until the patentee receives his patent rights.

It is said that this fuel apparently solves the question of the air-cooled engine. No carbon sediment is formed in the cylinder, and the fuel is claimed to be non-injurious to the carburetor and engine. No special carburetor is required. Acetol mixes with gasoline. The inventor claims that it has a wider explosive range than the ordinary marketed gasoline—i.e., both a weaker and an over-rich charge in the cylinder heads will fire when gasoline fritters out or chokes. Tests made with this fuel are said to have produced very satisfactory results.

It is claimed that acetol can be manufactured much more cheaply than the present cost of gasoline in South Africa. The retail selling price of gasoline at the coast ports of that country, which is fixed by the government, is $1.12 per imperial gallon (1¼ American gallons) if purchased in cases of two cans containing 4 gal. each, and $1.22 per gal. if purchased in smaller quantities. Natalite now sells for 60c. per gal.

Non-Metal Industries Looking Up

After a visit to the principal centers of production of non-metals in the Mississippi Valley, R. P. Ladoo of the Bureau of Mines has returned to Washington with the report that a new spirit seems to characterize this industry. Businesslike methods are being adopted by even the smallest operators. Waste is being eliminated and economies of various natures are being adopted. In many cases the most improved machinery is being installed.

The most important single activity seems to be in bauxite production. In that industry there is a decided tendency to undertake large preliminary expense so as to achieve ultimate economies and maximum production. The labor shortage is being met by the employment of Mexicans, who are reported to be giving entire satisfaction.

The market for tripoli is widening, with the result that greater activity is being manifested in its mining and treatment. The success with which the flour of this material is being used as a filler for rubber and in

foundries as a parting for molds has added importantly to the demand.

While some of the smaller fluorspar operations are closed, all of the large companies are operating at a maximum capacity. Mr. Ladoo believes this to be largely because the more highly organized companies produce a more uniform grade of product. An indication of the promising outlook for that industry is the recent decision to erect a $1,000,000 mill on the Rosiclare vein in southern Illinois. Mr. Ladoo also found the flint clay and diaspore industries enjoying general prosperity.

New Italian Process for the Manufacture of Synthetic Ammonia

In the manufacture of synthetic ammonia by the Haber process the great difficulty encountered is that the catalyzers soon become poisoned. The correction of this difficulty constitutes the essence of the new Italian process for producing synthetic ammonia. After long experimentation, a catalyzer has been found which continues to function despite any impurities in the hydrogen and nitrogen gases. Further, an extremely simple apparatus for its employment has been developed. Nature herself many be said to employ a species of catalytic process in rendering atmospheric nitrogen available to the soil. Certain leguminous plants, as cowpeas and clovers, appropriate atmospheric nitrogen and store it up in their root nodules, transferring it thence to the soil.

In the synthesizing plant at Terni, about sixty miles north of Rome, the only raw materials used are the air and water. With a limited equipment it produces about 300 kilos (kilo = 2.2 lb.) of ammonia per day. Water power in abundance is furnished by the adjacent falls at Terni. The energy of the falling water is converted into electricity and the water, in turn, is acted upon by the electric current to produce hydrogen. This gas is then piped to the apparatus which extracts nitrogen from the air. Being a trade secret, the process of this extraction cannot be explained fully. It is carried on in a large steel cylinder resembling the upright boiler of a 50-hp. double-drum, stationary hoisting engine. The apparatus works automatically, running for days without attention. The nitrogen-hydrogen mixture is led from the boiler-like receptacle, heated, and passed under low pressure into a tube-like cylinder, where it is conducted through the catalytic substance. Here the desired combination takes place. The ammonia thus produced is condensed into liquid form by a refrigerating apparatus and drawn off from time to time in steel cylinders. It is put on the market in these cylinders at prices which are said to be at least 100 per cent above the cost of production. The whole apparatus, aside from the cells for producing the hydrogen, easily can be made to occupy a space of about 625 sq.ft. Just now the plant is undergoing enlargement, its capacity by Dec. 1 to be at least 1,000 kilos of pure ammonia per day.

Dr. Casale, the Italian inventor of the process, has gone even further in his work of synthesizing ammonia, having practically completed a process of utilizing this product in the manufacture of urea. This substance, by reason of its high nitrogen content of 45 per cent and carbon dioxide remainder, is a most valuable source of soil fertilizer and is chemically classed with that ancient restorer, barnyard manure.

The development of this new Italian process from a purely theoretical to a commercially fruitful status has been made possible through the interest and financial backing of an American capitalist. Some time ago this American secured a concession from the Italian Government for water-power rights at Terni, and is now negotiating for other concessions which will enable him to duplicate the Terni facilities.

Industrial Nurses Convene at New Haven

A convention of industrial nurses, the first of its kind, was held this fall at the New Haven School for Public Health Nursing. Fifty-four registered public health nurses from eight states attended. The varied industries represented and the discussions of the nurses brought out very clearly the fact that, while no fixed rules can be worked out to fit all places, it is possible to state definitely the fundamental principles of industrial nursing.

There were representatives from a university mercantile department, a state department of health, visiting nurse associations; canning, packing, chocolate and soap industries; woolen and cotton mills; brass and iron foundries; wire and paper mills; manufacturers of leather and rubber goods; monument, typewriter and corset works; roller bearings, sporting goods, tools and electrical appliances; printing and oil plants. The states represented were Connecticut, Massachusetts, New York, Rhode Island, New Jersey, New Hampshire, Illinois and Michigan.

The program lasted ten days and included lectures and round tables on Public Health Nursing, Industrial Nursing, Industrial Hygiene, Industrial Diseases, Records, Ethics of Industrial Nursing and Medicine, Industrial Relations, Social Problems, Industrial Psychology, Nutrition, Health Education, as well as excursions to manufacturing plants. Four periods were given over to lectures on recreation and other methods for counteracting industrial monotony. Play demonstrations were given and every one joined in folk dancing and simple games.

Book Reviews

MANUAL OF CYANIDATION. By *E. M. Hamilton.* 278 pages, illustrated. New York: McGraw-Hill Book Co. Price $3.

In this excellent little text of 253 reading pages Mr. Hamilton presents in very readable form and with little surplus verbiage the essential features of the cyanide process as now practiced. The book is written in a suggestive style, with many definite references to original sources, and should prove useful to those practically engaged in cyanidation, and also as a textbook for technical schools giving instruction in the metallurgy of gold and silver. The typographical work is good, the book of convenient pocket size and well bound in flexible cloth, an improvement over the flexible leather of a few years ago.

The chemistry of cyaniding is presented in Chapter I, and the control of operations by testing of various kinds in Chapters II and III, the former dealing with the tests required on solutions, and the latter with general testing of ores as to their suitability for treatment by cyaniding, and best conditions of treatment. The chief methods of employing the process are then taken up under the headings of "Sand Leaching," "Slime Treatment" and "Milling in Cyanide Solution." These chapters constitute a very satisfactory description of the ordinary apparatus and principles and conduct of the several processes. The causes of

discrepanices between actual recovery and theoretical extract'on are discussed in Chapters VI, VII and VIII with a view to their relative seriousness and control. Telluride and other ores presenting special difficulties are discussed in a separate chapter. The recovery of gold and silver from solutions is covered in Chapter I on "Precipitation" and Chapter II on "Cleaning Up and Melt'ng." In the last two chapters are given representative plant costs and data and a considerable number of tables of miscellaneous information, the data in both chapters being well chosen for their practical value and suggestiveness.   S. L. GOODALE.

* * *

HANDBOOK OF ORE DRESSING. By *A. W. Allen.* 242 pages, illustrated. New York: McGraw-Hill Book Co. Price $3.

In this book Mr. Allen has brought together a great deal of informat'on and presented it in small compass and easily accessible form. There are 230 pages of reading matter, tables and illustrations, and a short bibliography. The book is of pocket size, well bound in flexible cloth, and the presswork is good, the type even in the tables large enough to be easily read. Most of the data are presented in tabular or diagrammatic form with directions for use of the tables and diagrams. There are a large number of excellent cuts of machinery and apparatus, with short description accompanying each, but not going into minute detail. Comparative data as to machines and processes are frequently presented and should prove of real value. The theoretical matter of interest in ore dressing is taken up as fully as the space of the volume permits, and it seems that the book should find much use in the libraries of all engineers who handle ore-dressing problems.   S. L. GOODALE.

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LABORATORY MANUAL OF ELEMENTARY COLLOID CHEMISTRY. By *Emil Hatschek.* Philadelphia: P. Blakiston's Son & Co., 1920. 133 pp., with 20 illustrations. Price $2 net.

In this welcome little manual there are compressed a large number of practical exercises in colloid chemistry, involving simple and inexpensive apparatus and modified by the author's teaching experience. "————the guiding principle has been to provide for the wants of those students of numerous branches of science who are finding some training in colloid chemistry an indispensible part of their equipment, and are able to devote a limited time only to acquiring its technique. For the guidance of readers desirous of going beyond the limits of this manual a number of references to recent literature are given at the end of each section."

The chapters are: General remarks on apparatus, mater'als and procedure; dialysis; suspensoid sols; suspensions; organosols; emulsoid sols and gels; egg albumin sol; emulsions; ultra-filtration; optical methods of examination; cataphoresis; electrolyte precipitation of suspensoid sols; mutual precipitation of suspensoid sols; protection; viscosity measurements; absorption (qualitative experiments); capillary analysis; determination of an adsorption isotherm; the Liesegang phenomenon.

There are many bits of simple but necessary advice such as to avoid pouring a viscous sol into a thin solvent during dilution; for although common sense and "kitchen experience" should indicate the reverse order, the beginner is apt to proceed hastily and get into trouble.

The instructions are for the most part very clearly and concisely given. But on p. 32 the author says regarding the preparation of colloidal silver by Carey Lea's method: "The color of the sol, and in fact the success of the whole method, depends a good deal on the quality of the dextrine, which can be determined only by experiment." It seems to the reviewer that it should be easy to give specifications for the quality and kind of dextrine best suited for this purpose.

The author adheres to Wo. Ostwold's classification of colloids into "suspensoids" and "emulsoids," but Zsigmondy's classification into "reversible" and "irreversible" colloids seems more desirable. Thus on p. 35 (footnote) the author says regarding ferric hydroxide sol: "Although this sol has some emulsoid properties, it is classed here with the

suspensoids on account of its behavior to electrolytes, etc." On p. 41 some specification should be given as to the kind of commercial waterglass to be used, for the commercial grades vary widely in their ratio of SiO_2 to Na_2O. It is interesting to note that ammonium thiocyanate exercises marked protective action on colloidal SiO_2. A very s'mple optical method for determining the setting point of gelatine solution is based on the fact that during the last stage of setting the surface of the sol forms a network of wrinkles (which are not due to drying). On p. 64 reference is made to Stokes' formula, but the formula is not given, as it should be, to save the student the trouble of looking it up. The size of the chapter on "protection" is not commensurate with the importance of the phenomenon.

Regarding Liesegang's rings, it is stated: "To produce really good rings the gelatine must contain a small amount of acid and of gelatose (a product of hydrolysis which does not gelatinize on cooling)." This would indicate that the reaction takes place in the diffusion paths formed by the dispersion medium, where the protective action of the gelatose should be a factor.

The book fills a want not only because of its intrinsic merit, but also because it is the first of its type.
    JEROME ALEXANDER.

Personal

A. W. AMBROSE will become chief petroleum technologist of the Bureau of Mines on Nov. 15. He succeeds J. O. Lewis, who has resigned to enter private employment. Mr. Ambrose is a native of California and is a graduate of the College of Mining at Stanford University. He spent a number of years on work dealing with the relation of geology to drilling and production in the California, Texas and Louisiana oil fields. He has been with the Bureau of Mines since 1917. Since Feb. 1 he has been superintendent of the bureau's petroleum station at Bartlesville, Okla.

C. W. BATES has recently accepted a position in the engineering department of the Anaconda Lead Products Co., East Chicago, Ind.

WARREN F. BLEECKER, metallurgical engineer, of Boulder, Col., was in New York last week on a business and professional trip.

General Sir ARTHUR CURRIE, former commander-in-chief of the Canadian army in France and now principal of McGill University, Montreal, visited Chicago recently and was entertained at luncheon by David R. Forgan. He later addressed a joint meeting of the Canadian Club and McGill Alumni at the Morrison Hotel, and outlined McGill University's need of additional funds to make up for losses during the war. A campaign will be launched on Nov. 15 for $5,000,000, to include building equipment for the university and living wages for McGill's faculty.

Dr. F. L. DEBEUKELAER, who received his Ph.D. degree from the University of Chicago last summer, is now employed as research chemist in the glue and gelatine department of Swift & Co., Chicago, Ill.

GORDON FOX, formerly with the Fort Wayne works of the General Electric Co. and lately electrical engineer of the Mark plant of the Steel & Tube Co. of America, has joined the staff of Freyn, Brassert & Co., engineers, Chicago, Ill., in the capacity of electrical engineer. Mr. Fox is chairman of the Chicago Section of the Association of Iron and Steel Electrical Engineers.

LOUIS D. HUNTOON and G. D. VAN ARSDALE have formed a partnership under the name of Huntoon & Van Arsdale, and will engage in consulting engineering in mining, metallurgy and geology. As previously announced, Mr. Van Arsdale will be in Los Angeles, while Mr. Huntoon will remain in New York City.

I. O. JUVRUD has been appointed chief chemist for the Portland Flouring Mills Co. of Portland, Ore. His former

work in this line has been with the Kansas Milling Co. of Wichita, Kan., and the Atkinson Milling Co. of Minneapolis.

HARLAN S. MINER of the Welsbach Co. addressed the Eastern Section of the American Chemical Society at Union College, Schenectady, N. Y., on Nov. 5, on the subject of "Thorium, Mesothorium, Cerium and Other Rare Earths."

ABRAHAM A. ORLINGER, holder of the New York Chemists' Club Hoffman scholarship for 1919-20, has been awarded the scholarship for 1920-21. Mr. Orlinger is completing the chemical engineering course at the Massachusetts Institute of Technology.

D. L. SCOLES, who has been at the Iowa State College at Ames, Iowa, for five years, has resigned as assistant professor of chemistry to accept a position as head of the department of chemistry at Illinois Wesleyan University, Bloomington, Ill.

Dr. LEE IRVIN SMITH, who was formerly an instructor in chemistry at Harvard University, is now instructor in organic chemistry, University of Minnesota, Minneapolis, Minn.

NEWTON W. SPEECE, who served two and one-half years during the year as a Captain of infantry, with over a year's service in France, is now instructor of chemistry at the University of Minnesota, Minneapolis, Minn. Mr. Speece is a graduate and post-graduate of Dickinson College, Carlisle, Pa.

R. B. STRINGFIELD, formerly superintendent of the chemical department of the Pacific Minerals. & Chemical Co. and chemical engineer with the Arthur R. Maas Laboratories of Los Angeles, has accepted a position as chemical engineer with the Goodyear Tire & Rubber Co. of California, Los Angeles.

Current Market Reports

The Iron and Steel Market

Pittsburgh, Pa., Nov. 5, 1920.

Pig iron production in October was at a slightly lower rate than in September by the merchant furnaces, but at a materially greater rate by the steel works furnaces, so that on the whole there was a slight increase. Many furnaces blew out late in October, however, so that the rate at the close of the month was well below the average rate in September. In the rate of steel ingot production there was probably a decrease from September to October, taking the months entire, while the rate now is well below the October average, being probably between 10 and 15 per cent below the rate of 42,700,000 tons per annum in ingots shown for both September and August.

The Steel Corporation's output has not decreased, but if anything has increased. One or two large independents seem to be operating at as heavy a rate as formerly, but nearly all independents are at reduced rates. In some cases the reductions are small, in other cases large. Not a few plants are operating at less than 60 per cent. In all cases it is a matter of order books. The volume of business on books is in inverse ratio to the prices charged. Independents that were relatively conservative in the matter of prices have such order books that, despite cancellations and postponements, they can operate at fair rates, say above 75 per cent. Others, with lean order books, must be contented with lower rates, even though they seek new business at cut prices. There is not much business to be drawn out by cutting prices, and the cuts proceed by easy stages.

In not one case thus far is an independent selling any steel product at the Steel Corporation or Industrial Board price. The expectation is practically universal that the independent market will decline to the Steel Corporation level, and the whole market will then be equalized, except for such cutting as some independents may be forced to indulge in so as to regain lost customers. The chief question debated is how long the process of equalization will require. Some say by January, some by April, the readjustment will be completed.

A possible objection to the prediction is that it is so universal. Some say "majorities are always wrong." On the other hand, it may be urged that if a buying movement occurs in steel after a period of dullness it takes care of itself, the buying producing a stiffening in the market, and the stiffening producing additional buying. It is said that what is needed is "confidence," and if every one expects the steel market to decline to the Steel Corporation level and then stop, certainly there should be confidence in the market when it gets to that point.

STEEL PRICES

There are no longer any delivery premiums, except as it may be said that independent prices represent delivery premiums on account of their being above Steel Corporation prices, with the Steel Corporation very well sold up. Purchases are not being made from independents for extended deliveries, so that the prompt market is all there is in the independent market. Prices are roughly as follows, the Steel Corporation price being named first and the independent price next: Bars, 2.35c. and 3c.; shapes, 2.45c. and 2.90c. or 3c.; plates, 2.65c. and 3c.; nails, $3.25 and $4.25; standard steel pipe, 57½ and 54 per cent off list; blue annealed sheets, 3.55c. and 5c.; black sheets, 4.35c. and 6.25c.; galvanized sheets, 5.70c. and 7.75c.; tin plate, $7 and $8.50. In the case of sheets and tin plate the corporation is not a seller, but it will open its books next month for first half contracts with regular customers, to be filled after the carried-over business is completed, this requiring approximately the first three months of the new year.

PIG IRON

Pig iron having reached such a remarkable height, and the last of the advances, in August, having been accompanied by such light sales, the market is simply yielding a competitive amount almost every time an inquiry for an important tonnage arises. Foundry has shown no important inquiry, hence remains quotable nominally at $45 valley. Basic, which was $40 valley, yielded, on a 2,000-ton transaction, to $38.50. An interesting feature of this transaction was that the buyer was entirely out of valley territory, being in the East. Apparently the Eastern furnaces were not quick enough to reduce their quotations. Bessemer has declined from $45 to $42 valley, through a furnace interest voluntarily electing to offer iron at the lower price, to avoid bessemer and basic prices being too completely estranged from each other.

Conjectures are now being made as to where pig iron will find its resting or turning point. While steel prices are expected to land at the Industrial Board schedule, the case of pig iron may be different. The Industrial Board prices were: Basic, $25.75; foundry, $26.75; bessemer, $27.95. The furnaces adopted these prices, but under more or less protest, claiming they were too low, relative to steel. The Industrial Board schedule became effective March 21, 1919, and a trifle more than six months later pig iron began to advance, being made scarce by the iron and steel strike. However, a price of $28 or $29 in the Industrial Board schedule would have satisfied the furnacemen at the time, as being in suitable relation with steel. Coke, however, not mentioned in the Industrial Board schedule, was obtainable by furnaces to make iron at Industrial Board prices at between $3.50 and $4, whereas on account of coal conditions coke seems quite unlikely to decline to anything like that figure. In the past three weeks Connellsville furnace coke for spot shipment has declined from $17 to $9, but the decline is beginning to show signs of halting. Coke and pig iron must both find their levels, but the question which is going to control the other proves much more serious than the query as to priority between the chicken and the egg. Common guesses are that pig iron will land somewhere between $30 and $35 and coke somewhere between $6 and $8.

The Chemical Allied and Industrial Markets

New York, Nov. 6, 1920.

The general condition of the chemical market is hardly active, but is distinctly optimistic—as a result of the election. Price changes, with few exceptions, have continued to favor buyers. *Caustic soda* showed a tendency to resist the downward movement and supplies in the past week have become very light. Manufacturers were quoting $3.75 per cwt., basis 60 per cent, on contract over next year, with large business transacted among the leading soap makers. The spot market was firm at $4.30@$4.40 per cwt. Another item meriting interest is *bleaching powder.* Rolling material was very scarce, with prices ranging from 6½@6¾c. November shipment from works could be obtained at 6c. lb. Manufacturers reported sales to large paper mills over next year at 3¾c. per lb. in large drums f.o.b. works. *Soda ash* seemed to be moving along in sympathy with *caustic soda.* Contracts over next year were placed at $1.85 per cwt., basis 48 per cent, f.o.b. works. *Bichromate of soda* remained quiet, with a few small sales made at 11½c. per lb. *Bichromate of potash* was one of the weak items with sales recorded as low as 22½c. per lb.

COAL-TAR PRODUCTS

Trading in the coal-tar products market was along quiet lines, and what little business was obtainable was considerably interfered with by election talk. In a great many quarters the general tone is very optimistic, and the hope of an early resumption of activity was more favorably expressed. There were only a few changes in the price list, with *pure benzene* quoted at 35@40c. per gal., and the 90 per cent at 33@38c. per gal. *Cresylic acid* was in easy supply, with the market ranging from 95c.@$1.15 per gal. Intermediates were in light call with *paranitraniline* as a leading feature. Large orders were on the market at $1.10 per lb., but holders seemed to expect an active market and were holding for $1.15 per lb. *Beta naphthol* was quoted over next year at 48@52c. per lb., with very little business obtainable. *Benzoic acid* is in fair demand and supplies are available at 80@85c. per lb.

CRUDE RUBBER

The optimism which is being generally manifested over the outcome of the recent presidential election is utterly lacking in the crude rubber market. *First latex crêpe* is quoted at 21c., while the price in January, 1920, was 54c. per lb. This represents a loss of $660 per ton in less than a year. This condition has been brought about by a combination of circumstances—overestimation by tire producers of this year's consumption, the speculative element that entered the market early in the year and the continued rise in the cost of production of rubber goods. During the last ten months it is estimated twenty firms have failed, some of that number being old-established firms and others fly-by-night speculators that infested the industry. The Rubber Trade Association has seven firms under consideration regarding the settlement of their affairs before entering bankruptcy and ten other cases will come up next week.

In India conditions are still worse. The cost of production to the plantation owner is said to be 27c., while the same material is being offered on the local market at 21c. per lb. The amount of unsold and unused material is estimated at 200,000 tons, which is equivalent to two-thirds the yearly consumption. This surplus is distributed among tire manufacturers, who hold 65,000 tons, local market 35,000 tons, England 30,000 tons and the remainder held in the Far East.

MISCELLANEOUS MATERIALS

There has been a big drop in *coke* during the last two weeks owing to the sudden falling off in demand. Foundry is listed at $11@$11.50 and furnace at $10@$10.50 per net ton f.o.b. ovens. *Tungsten* ore has been quiet for some time, with offerings of $6 per unit for scheelite and $4.50@$5 for wolframite. These prices do not meet with the approval of buyers, who have been consistently holding out for lower levels.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots		Less Carlots	
Acetic anhydride	lb.	—		$0.65 –	$0.75
Acetone	lb.	$0.15½ –$	0.16½	.16½ –	.17
Acid, acetic, 28 per cent	100 lbs.	3.50 –	3.75	4.00 –	4.50
Acetic, 56 per cent	100 lbs.	7.50 –	8.00	8.50 –	9.50
Acetic, glacial,99½ per cent, carboy	100 lbs.	11.50 –	12.00	12.50 –	
Boric, crystals	lb.	.15½ –	.16	.16½ –	.19
Boric, powder	lb.	.15½ –	.16½	.17 –	.20
Citric	lb.	.55 –	.56	.57 –	.58
Hydrochloric (nominal)	100 lb.	1.85 –	2.25	2.75 –	3.00
Hydrofluoric, 52 per cent (nominal)	lb.	.15 –	.16	.16½ –	.18
Lactic, 44 per cent tech	lb.	.10 –	.11½	.12 –	.16
Lactic, 22 per cent tech	lb.	.04½ –	.05½	.06 –	.07
Molybdic, C. P.	lb.	4.00 –	4.50	4.50 –	5.00
Muriatic, 20 deg. (see hydrochloric)					
Nitric, 40 deg.	lb.	.07 –	.07½	.08 –	.08½
Nitric, 42 deg.	lb.	.07½ –	.08	.08½ –	.09½
Oxalic, crystals	lb.	.27 –	.28	.29 –	.31
Phosphoric, Ortho, 50 per cent solution	lb.	.19 –	.20	.21 –	.22
Picric	lb.	.28 –	.35	.40 –	.50
Pyrogallic, resublimed	lb.	2.30 –	2.55	2.60 –	2.65
Sulphuric, 60 deg., tank cars	ton	11.00 –	12.00	—	
Sulphuric, 60 deg., drums	ton	—		—	
Sulphuric, 66 deg., tank cars	ton	16.00 –	17.00	18.00 –	20.00
Sulphuric, 66 deg., drums	ton	21.00 –	22.00	—	
Sulphuric, 66 deg., carboys	ton	—		—	
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –	30.00	37.00 –	42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	30.00	38.00 –	42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 –	35.00	40.00 –	
Tannic, U. S. P.	lb.	1.45 –	1.50	1.55 –	1.65
Tannic (tech.)	lb.	.60 –	.70	.80 –	.90
Tartaric, crystals	lb.	.53 –	.55	.56 –	.57
Tungstic, per lb. of WO.	lb.	—		1.20 –	1.40
Alcohol, Ethyl (nominal)	gal.	5.50 –	5.75	—	
Alcohol, Methyl (see methanol)		—		—	
Alcohol, denatured, 188 proof (nominal)	gal.	—		1.12 –	1.15
Alcohol, denatured, 190 proof (nominal)	gal.	—		1.05 –	1.10
Alum, ammonia lump	lb.	.04½ –	.04½	.05 –	.05½
Alum, potash lump	lb.	.05½ –	.06	.06½ –	.07
Alum, chrome lump	lb.	.14½ –	.15	.16 –	.17
Aluminum sulphate, commercial	lb.	.03½ –	.03½	.04 –	.04½
Aluminum sulphate, iron free	lb.	.04½ –	.05	.05½ –	.06
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ –	.09½	.09½ –	.10½
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 –	.35	.36 –	.38
Ammonium carbonate, powder	lb.	.14½ –	.15½	.16 –	.16½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.14 –	.14½	.14½ –	.15
Ammonium chloride, granular (gray salammoniac)	lb.	.12 –	.13	.13½ –	.14½
Ammonium nitrate	lb.	—	.10	.11 –	.14
Ammonium sulphate (f.o.b. New Orleans)	lb.	.05 –	.05½	.06 –	.06½
Amylacetate	gal.	—		4.50 –	5.00
Amylacetate tech	gal.	—		4.00 –	4.20
Arsenic, oxide, lumps (white arsenic)	lb.	.14 –	.14½	.15 –	.16
Arsenic, sulphide, powdered (red arsenic)	lb.	.18 –	.19	.19½ –	.20
Barium chloride	ton	90.00 –	95.00	100.00 –	105.00
Barium dioxide (peroxide)	lb.	.24 –	.25	.26 –	.27
Barium nitrate	lb.	.12 –	.12½	.13 –	.13½
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ –	.05	.05½ –	.06
Bleaching powder (see calcium hypochlorite)					
Blue vitriol (see copper sulphate)		—		—	
Borax (see sodium borate)					
Brimstone (see sulphur, roll)					
Bromine	lb.	.70 –	.80	.85 –	.90
Calcium acetate	100 lbs.	3.50 –	3.55	—	
Calcium carbide	lb.	.05½ –	.06	.06½ –	.06½
Calcium chloride, fused, lump	ton	30.00 –	32.00	33.00 –	35.00
Calcium chloride, granulated	lb.	.02 –	.02½	.03 –	.03½
Calcium hypochlorite(bleaching powder)	lb.	.06 –	.06½	.07 –	.07½
Calcium peroxide	lb.	—		1.50 –	1.70
Calcium phosphate, monobasic	lb.	—		.75 –	.80
Calcium sulphate, pure	lb.	—		.25 –	.30
Camphor	lb.	—		1.10 –	1.15
Carbon bisulphide	lb.	.08 –	.09	.10 –	.11
Carbon tetrachloride, drums	lb.	.13 –	.14	.16 –	.17
Carbonyl chloride (phosgene)	lb.	—		1.25 –	1.50
Caustic potash (see potassium hydroxide)					
Caustic soda (see sodium hydroxide)				—	
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 –	.09½	.10 –	.10½
Chloroform	lb.	.40 –	.43	.44 –	.47
Cobalt oxide	lb.	—		4.00 –	4.10
Copperas (see iron sulphate)					
Copper carbonate, green precipitate	lb.	.27 –	.28	.29 –	.31
Copper cyanide	lb.	—		.65 –	.70
Copper sulphate, crystals	lb.	.07½ –	.08	.08½ –	.09
Cream of tartar (see potassium bitartrate)					
Epsom salt (see magnesium sulphate)					
Ethyl Acetate Com. 85%	gal.	—		1.05 –	1.10
Ethyl Acetate pure (acetic ether 98% to 100%)		—		—	
Formaldehyde, 40 per cent (nominal)	lb.	.27 –	.28	.29 –	.30
Fusel oil, ref	gal.	—		4.25 –	4.50
Fusel oil, crude (nominal)	gal.	—		3.25 –	3.50
Glauber's salt (see sodium sulphate)					
Glycerine, C. P. drums extra	lb.	—		.27½ –	.28
Iodine, resublimed	lb.	4.30 –	4.35	4.40 –	4.45
Iron oxide, red	lb.	—		.15 –	.25
Iron sulphate (copperas)	100 lbs.	2.00 –	2.25	2.35 –	2.75
Lead acetate, normal	lb.	—		.13½ –	.16
Lead arsenate (paste)	lb.	.13 –	.14	.14½ –	.15
Lead nitrate, crystals	lb.	—		.90 –	1.00
Litharge	lb.	.12 –	.12½	.13 –	.13½
Lithium carbonate	lb.	—		1.50 –	
Magnesium carbonate, technical	lb.	.11½ –	.12	.12½ –	.13
Magnesium sulphate, U. S. P.	100 lb.	3.00 –	3.25	—	
Magnesium sulphate, commercial	100 lb.	—		3.50 –	3.60
Methanol, 95%	gal.	—		2.70 –	2.75
Methanol, pure	gal.	—		2.90 –	3.00
Nickel salt, double	lb.	—		.14 –	.16
Nickel salt, single	lb.	—		.13 –	.14
Phosgene (see carbonyl chloride)					
Phosphorus, red	lb.	.50 –	.55	.60 –	.65
Phosphorus, yellow	lb.	—		.35 –	.37
Potassium bichromate	lb.	.23 –	.24	.24½ –	.25

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$0.49 – $0.50	$0.51 – $0.53
Potassium bromide, granular	lb.		.50 – .55
Potassium carbonate, U. S. P.	lb.	.50 – .55	.56 – .60
Potassium carbonate, crude	lb.	.18½ – .19	.19½ – .20
Potassium chlorate, crystals	lb.	.18 – .18½	.19 – .20
Potassium hydroxide (caustic potash)	lb.	.18 – .19	.19½ – .20
Potassium iodide	lb.	–	3.20 – 3.30
Potassium nitrate	lb.	.14 – .16	.16½ – .17
Potassium permanganate	lb.	.63 – .68	.70 – .75
Potassium prussiate, red	lb.	.73 – .75	.78 – .80
Potassium prussiate, yellow	lb.	.36 – .37	.37½ – .38½
Potassium sulphate (powdered)	ton	240.00 – 255.00	
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)		–	
Sal soda (see sodium carbonate)			
Salt cake	ton	–	52.00 – 55.00
Silver cyanide (nominal)	oz.		1.25 –
Silver nitrate (nominal)	oz.	–	.60 – .62
Soda ash, light	100 lb.	2.15 – 2.25	2.30 – 2.50
Soda ash, dense	100 lb.	2.75 – 2.90	3.00 – 3.25
Sodium acetate	lb.	.08½ – .09	.09½ – .09½
Sodium bicarbonate	100 lb.	2.90 – 3.00	3.25 – 3.50
Sodium bichromate	lb.	.11½ – .11½	.12 – .12½
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 11.00
Sodium bisulphite powdered, U.S.P.	lb.	.06½ – .07½	.08 – .09
Sodium borate (borax)	lb.	.09½ – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	2.00 – 2.10	2.15 – 2.25
Sodium chlorate	lb.	.14½ – .15	.15½ – .16½
Sodium cyanide, 96-98 per cent	lb.	.28 – .30	.31 – .32
Sodium fluoride	lb.	.20 – .20½	.21 – .22
Sodium hydroxide (caustic soda)	100 lb.	4.30 – 4.40	–
Sodium hyposulphite	lb.	–	.04 .04½
Sodium molybdate	lb.	2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 –	3.25 –
Sodium nitrite	lb.	.08½ – .08½	.09 – .09½
Sodium peroxide, powdered	lb.	.50 – .51	.51½ – .52
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodum potassium tartrate (Rochelle salts)	lb.		.37 – .38
Sodium prussiate, yellow	lb.	.22½ – .22½	.23 – .23½
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01½	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt) 100 lbs.		2.15 – 2.50	2.60 – 2.75
Sodium sulphide, crystal, 60–62 per cent (conc.)	lb.	.07 – .07½	.07½ – .08
Sodium sulphate, crystals	lb.	.04 – 0.4½	.04½ – .05
Strontium nitrate, powdered	lb.	.20 – .20½	.21 – .22
Sulphur chloride red	lb.	.08 – .09	.10 – .10½
Sulphur, crude	ton	16.00 – 20.00	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	–	3.70 – 4.35
Sulphur, roll (brimstone)	100 lb.	–	3.40 – 3.90
Tin bichloride, 50 per cent	lb.	.18 – .19	
Tin oxide	lb.	–	.50 – .51
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.12 – .13	.13½ – .14
Zinc cyanide	lb.	.45 – .49	.50 – .60
Zinc dust	lb.	.12 – .13	.13 – .14
Zinc oxide, XX	lb.	.11 – .11½	
Zinc sulphate	lb.	.03½ – .03½	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 –	$1.15
Alpha-naphthol, refined	lb.	1.45 –	1.50
Alpha-naphthylamine	lb.	.50 –	.52
Aniline oil, drums extra	lb.	.77 –	.30
Aniline salts	lb.	.33 –	.34
Anthracene, 80% in drums (100 lb.)	lb.	.90 –	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 –	2.10
Benzidine, base	lb.	1.15 –	1.20
Benzidine sulphate	lb.	1.10 –	1.15
Benzoic acid, U.S.P.	lb.	.80 –	.85
Benzoate of soda, U.S.P.	lb.	.80 –	.90
Benzene, pure, water-white, in drums (100 gal.)	gal.	.35 –	.40½
Benzene, 90% in drums (100 gal.)	gal.	.33 –	.38½
Benzyl chloride, 95-97%, refined	lb.	.35 –	.40
Benzyl chloride, tech.	lb.	.25 –	.35
Beta-naphthol benzoate (nominal)	lb.	3.50 –	4.00
Beta-naphthol, sublimed (nominal)	lb.	.90 –	.95
Beta-naphthol, tech (nominal)	lb.	.53 –	.55
Beta-naphthylamine, sublimed	lb.	2.25 –	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 –	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 –	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 –	1.15
Cresylic acid, 95-97%, dark, in drums	gal.	1.05 –	1.10
Cresylic acid, 50%, first quality, drums	gal.	.65 –	.75
Dichlorbenzene	lb.	.07 –	.10
Diethylaniline	lb.	1.45 –	1.50
Dimethylaniline	lb.	1.00 –	1.05
Dinitrobenzene	lb.	.30 –	.37
Dinitrochlorbenzene	lb.	.27 –	.32
Dinitronaphthalene	lb.	.42 –	.45
Dinitrophenol	lb.	.40 –	.45
Dinitrotoluene	lb.	.38 –	.40
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 –	.40
Diphenylamine (nominal)	lb.	.80 –	.85
H-acid (nominal)	lb.	1.65 –	1.70
Meta-phenylenediamine	lb.	1.25 –	1.30
Monochlorbenzene	lb.	.18 –	.20
Monoethylaniline	lb.	1.75 –	2.25
Naphthalene crushed, in bbls. (250 lb.)	lb.	.09 –	.09½
Naphthalene, flake	lb.	.09 –	.09½
Naphthalene, balls	lb.	.09½ –	.10
Naphthionic acid, crude	lb.	.70 –	.75
Nitrobenzene	lb.	.12 –	.15
Nitro-naphthalene	lb.	.40 –	.50
Nitro-toluene	lb.	.18 –	.25
Ortho-amidophenol	lb.	3.20 –	3.75
Ortho-dichlor-benzene	lb.	.15 –	.20
Ortho-nitro-phenol	lb.	.75 –	.80
Ortho-nitro-toluene	lb.	.25 –	.40
Ortho-toluidine	lb.	.32 –	.35
Para-amidophenol, base	lb.	2.50 –	3.00
Para-amidophenol, HCl	lb.	2.50 –	3.00
Para-dichlorbenzene	lb.	.10 –	.15
Paranitroaniline	lb.	1.15 –	1.20

Para-nitrotoluene	lb.	1.25 –	1.40
Para-phenylenediamine	lb.	2.50 –	2.65
Para-toluidine	lb.	1.85 –	2.00
Phthalic anhydride	lb.	.60 –	.70
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 –	.14
Pyridine	gal.	2.00 –	3.50
Resorcinol, technical	lb.	3.25 –	3.50
Resorcinol, pure	lb.	4.50 –	5.00
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.35 –	.38
Salicylic acid, U. S. P.	lb.	.40 –	.45
Salol	lb.	.85 –	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.30 –	.35½
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 –	.22
Sulphanilic acid, crude	lb.	.32 –	.35
Tolidine	lb.	1.75 –	1.80
Toluidine, mixed	lb.	.45 –	.55
Toluene, in tank cars	gal.	.35 –	
Toluene, in drums	gal.	.41 –	.42
Xylidines, drums, 100 gal.	lb.	.50 –	.65
Xylene, pure, in drums	gal.	.45 –	.47
Xylene, pure, in tank cars	gal.	.45 –	
Xylene, commercial, in drums, 100 gal.	gal.	.37 –	.38
Xylene, commercial, in tank cars	gal.	.30 –	

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.30 –	$0.32
Beeswax, refined, light	lb.	.34 –	.37
Beeswax, white pure	lb.	.55 –	60
Carnauba, No. 1 (nominal)	lb.	.90 –	.95
Carnauba, No. 2, regular (nominal)	lb.	.75 –	.80
Carnauba, No. 3, North Country	lb.	.25 –	.26
Japan	lb.	.18 –	.20
Montan, crude	lb.	.12 –	.14
Paraffine waxes, crude match wax (white) 105–110 m.p.	lb.	.09 –	.09½
Paraffine waxes, crude, scale 124–126 m.p.	lb.	.08½ –	.0¾
Paraffine waxes, refined, 118–120 m.p.	lb.	.10½ –	.10
Paraffine waxes, refined, 125 m.p	lb.	.11 –	.11½
Paraffine waxes, refined, 128–130 m.p.	lb.	.12 –	.12½
Paraffine waxes, refined, 133–135 m.p.	lb.	.15 –	.15½
Paraffine waxes, refined, 135–137 m.p.	lb.	.16 –	.16½
Stearic acid, single pressed	lb.	.17½ –	.17½
Stearic acid, double pressed	lb.	.18½ –	.19
Stearic acid, triple pressed	lb.	.22½ –	.23

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.90
Pine oil, pure, dest. dist.	gal.	1.50
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$12.75 –	
Rosin E-I	280 lb.	12.75 –	
Rosin K-N	280 lb.	12.75 –	
Rosin W. G.-W. W.	280 lb.	13.00 –	13.25
Wood rosin, bbl.	280 lb.	11.00 –	
Spirits of turpentine	gal.	1.28 –	
Wood turpentine, steam dist.	gal.	1.22 –	
Wood turpentine, dest. dist.	gal.	1.18 –	
Pine tar pitch, bbl.	200 lb.		8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.		15.00
Retort tar, bbl.	500 lb.	15.00 –	15.50
Rosin oil, first run	gal.	.70 –	
Rosin oil, second run	gal.	.73 –	
Rosin oil, third run	gal.	.90 –	

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine (nominal)	lb.	$0.26 –	$0.26½
Upriver coarse (nominal)	lb.	.17 –	.18
Upriver caucho ball (nominal)	lb.	.17½ –	.18½
Plantation—First latex crepe	lb.	.21 –	
Ribbed smoked sheets	lb.	.20 –	
Brown crepe, thin, clean	lb.	.17 –	
Amber crepe No. 1	lb.	.19 –	

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.16½ –	$0.18
Castor oil, AA, in bbls.	lb.	.15 –	.16
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.16 –	.16½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.15½ –	.16
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.17¼ –	.17½
Corn oil, crude, in bbls.	lb.	.12 –	.13
Cottonseed oil, crude (f.o.b. mill)	lb.	.10½ –	.11
Cottonseed oil, summer yellow	lb.	.13 –	.14
Cottonseed oil, winter yellow	lb.	–	
Linseed oil, raw, car lots (domestic)	gal.	1.07 –	
Linseed oil, raw, tank cars (domestic)	gal.	1.00 –	
Linseed oil, boiled, car lots (domestic)	gal.	1.09 –	

Olive oil, commercial	gal.	3.00	—	3.50
Palm, Lagos	lb.	.10½	—	.10¼
Palm, bright red	lb.		—	
Palm, Niger	lb.	.09½	—	.10
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.10½	—	.12½
Peanut oil, refined, in bbls.	lb.	.17	—	.18
Rapeseed oil, refined in bbls.	gal.	1.30	—	1.45
Rapeseed oil, blown, in bbls.	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.14	—	.14½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.10	—	.11

FISH

Light pressed Menhaden	gal.	$0.80	—	$0.90
Yellow bleached Menhaden	gal.	.83	—	.84
White bleached Menhaden	gal.	.86	—	.87
Blown Menhaden	gal.	.90	—	1.00

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24.00	—	$30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22.00	—	26.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00	—	12.00
Barytes, floated, f.o.b. St. Louis	net ton	26.50	—	28.00
Barytes, crude, first grade, Missouri	net ton	10.00	—	
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00½
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05½
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude, f.o.b. mines, Georgia	net ton	9.00	—	12.00
China clay (Kaolin) washed, f.o.b. Georgia	net ton	12.00	—	15.00
China clay (Kaolin) powdered, f.o.b. Georgia	net ton	18.00	—	22.00
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	8.00	—	14.00
Feldspar, crude, f.o.b. Maine	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00	—	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00	—	30.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00	—	
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00	—	
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite, crucible, 90% carbon, Ashland, Ala.	lb.		—	.09
Graphite, crucible, 85% carbon, Ashland, Ala	lb.	.07	—	.09
Graphite, higher lubricating grades	lb.	.11	—	.40
Pumice stone, imported, lump	lb.	.04	—	.50
Pumice stone, domestic, lump	lb.	.06	—	
Pumice stone, ground	lb.	.04	—	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton		—	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton		—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton		—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange fine	lb.		—	
Shellac, orange superfine	lb.	1.05	—	1.10
Shellac, A. C. garnet	lb.	.90	—	.95
Shellac, T. N.	lb.	.85	—	.95
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	12.00	—	22.00
Talc, roofing grades, f.o.b. Vermont	ton	9.50	—	15.00
Talc, rubber grades, f.o.b. Vermont	ton	12.00	—	18.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00	—	15.00
Talc, imported	ton	60.00	—	70.00
Talc, California Talcum Powder grade	ton	20.00	—	35.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	1,000		160
Chrome brick, f.o.b. Eastern shipping points	net ton		100–110
Chrome cement, 40-45% Cr₂O₃	net ton		55–60
Chrome cement, 40-45% Cr₂O₃, sacks, in car lots, f.o.b. Eastern shipping points	net ton		60–65
Fire clay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		55–60
Fire clay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		45–50
Magnesite brick, 9-in. straight	net ton		110
Magnesite brick, 9-in. arches, wedges and keys	net ton		121
Magnesite brick, soaps and splits	net ton		134
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000		65–70
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		56–61
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		55–60

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.18	—	.19
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.20	—	.21
Ferro-manganese, 76-80% Mn, domestic	gross ton	170.00	—	175.00
Ferro-manganese, 76-80% Mn, English	gross ton	165.00	—	170.00
Spiegeleisen, 18-22% Mn	gross ton	75.80	—	80.00
Ferro-molybdenum, 50-60% Mo, per lb. of Mo.	lb.	2.00	—	2.50
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.75	—	.90
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	8.50

Ores and Semi-finished Products

All f.o.b. Mines, Unless Otherwise Stated

Bauxite, 52% Al. content, less than 2% Fe₂O₃, up to 20½% silica, not more than 4½% moisture	gross ton	$10.00	—	$11.00
Chrome ore, Calif. concentrates, 50% min. Cr₂O₃	unit	.70	—	.75
Chrome ore, 50%, max., Cr₂O₃ f.o.b. Atlantic Seaboard	unit	.75	—	.85
Coke, foundry, f.o.b. ovens	net ton	11.00	—	11.50
Coke, furnace, f.o.b. ovens	net ton	10.00	—	10.50
Coke, petroleum, refinery, Atlantic Seaboard	net ton			
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50	—	
Fluor spar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	25.00	—	27.50
Ilmenite, 52% TiO₂, per lb. ore	lb.	.01½	—	.01½
Manganese Ore, 50% Mn, c i.f. Atlantic seaport	unit	.60	—	.70
Manganese ore, chemical (MnO₂)	gross ton	70.00	—	80.00
Molybdenite, 85% MoS₂, per lb. of MoS₂, N. Y.	lb.	.65	—	.70
Monazite, per unit of ThO₂	unit	35.00	—	
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12	—	
Pyrites, Spanish, furnace size, c.i.f., Atlantic seaport	unit	.16½	—	
Pyrites, Spanish, run of mines, c.i.f., Atlantic seaport	unit	.12	—	.14
Pyrites, domestic, fines	unit	.12	—	.14
Rutile, 95% TiO₂ per lb. ore	lb.	.15	—	
Tungsten, Scheelite, 60% WO₃ and over, per unit of WO₃ (nominal)	unit	6.00	—	
Tungsten, Wolframite, 60% WO₃ and over, per unit of WO₃, N. Y. C	unit	4.50	—	5.00
Uranium Ore (Carnotite) per lb. of U₃O₈	lb.	2.75	—	3.00
Uranium oxide, 96% per lb. contained U₃O₈	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore, per lb. of V₂O₅ contained	lb.	2.00	—	
Zircon, washed, iron free	lb.	.05	—	

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	14.75
Aluminum, 98 to 99 per cent	33.00
Antimony, wholesale lots, Chinese and Japanese	7.25
Nickel, ordinary (ingot)	43.00
Nickel, electrolytic	45.00
Tin, 5-ton lots	39.00
Lead, New York, spot	7.00–7.25
Lead, E. St. Louis, spot	6.80–7.05
Zinc, spot, New York	7.00
Zinc, spot, E. St. Louis	6.60

OTHER METALS

Silver (commercial)	oz.	$0.91½
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.55
Cobalt	lb.	6.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.75
Platinum	oz.	95.00@100.00
Iridium	oz.	400.00@450.00
Palladium	oz.	85.00
Mercury	75 lb.	60.00@62.50

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	25.50
Copper bottoms	35.00
Copper rods	30.00
High brass wire and sheets	28.50
High brass rods	20.25
Low brass wire and sheets	31.25
Low brass rods	25.00
Brazed brass tubing	37.25
Brazed bronze tubing	42.50
Seamless copper tubing	29.00
Seamless high brass tubing	28.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	One Year Ago	Cleveland	Chicago
Copper, heavy and crucible	12.50	17.00	12.00	13.50
Copper, heavy and wire	12.00	16.00	11.75	12.50
Copper, light and bottoms	10.00	14.00	10.00	11.00
Lead, heavy	5.50	4.75	5.50	6.00
Lead, tea	4.50	3.75	3.75	5.00
Brass, heavy	7.00	10.50	8.00	12.50
Brass, light	5.50	7.50	5.00	6.50
No. 1 yellow brass turnings	7.00	10.00	6.00	6.75
Zinc	4.50	5.00	3.75	5.00

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York Current	One Month Ago	One Year Ago	Cleveland Current	One Year Ago	Chicago Current	One Year Ago
Structural shapes	$4.30	$4.47	$3.47	$3.44	$3.37	$4.08	$3.47
Soft steel bars	4.75	4.62	3.37	3.84	3.27	3.98	3.37
Soft steel bar shapes	4.75	4.62	3.37	3.84	3.27	3.98	3.37
Soft steel bands	6.43	6.32	4.07	6.25			
Plates, ¼ to 1 in. thick	4.50	4.67	3.67	3.64	3.57	4.28	3.67

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

NEW HAVEN—H. Kasden, 19 Hone St., has awarded the contract for the construction of a 1-story, 50x80-ft. addition to his foundry on Mill River St., to J. Skolnick, 159 Columbus Ave. Estimated cost, $10,000.

PORTLAND—The Wilcox Crittenden & Co., Inc., 8 South Main St., Middletown, plans to build a 1-story foundry. Estimated cost, $50,000.

Florida

JACKSONVILLE—The William Toomer Fertilizer Co., Viaduct, plans to build a plant to replace the old one recently destroyed by fire. Cost to exceed $1,000,000. B. M. G. Prange, mgr. Noted June 16.

Illinois

CHICAGO—The Illinois Glass Co., 402 West Randolph St., has awarded the contract for the construction of a 1- and 2-story, 215x270 ft. factory, at 2601 North Crawford Ave., to Dahl Stedman Co., 11 South La Salle St.

CHICAGO—Stearns Bros. & Co., 619 South La Salle St., will soon award the contract for the construction of a 3-story, 100x160-ft. printing plant, on East Huron St. and Fairbanks Court. Estimated cost, $200,000. Berlin, Swern & Randall, 19 South La Salle St., archts.

ROCKFORD—The city plans to construct intercepting sewers at a cost of about $600,-000 and settling tanks and chlorination plant at a cost of about $220,000.

Indiana

ANDERSON—The Lavelle Foundry Co. is building a factory for the manufacture of gray iron castings. General foundry equipment and pattern shop machinery will be installed in same. J. F. Stanley, 1225 North Alabama St., Indianapolis, engr.

ELKHART—The Wawasee Tire & Rubber Co. will soon award the contract for the construction of a 4-story, 175x175-ft. factory. Estimated cost, $500,000. R. L. Simmons, archt.

FORT WAYNE—Griffith & Goodrich, archts., Physician's Defense Bldg., will receive bids about Nov. 25 for the construction of a 1- and 2-story, 60x180-ft. factory on Cochrane St., for the Amer. Textile Art Printing & Dyeing Co., 403 West Jefferson St. A water filtering and softening plant to have a capacity of 10,000 gal. in 8 hours will be installed in same. Estimated cost, $40,000.

Maryland

BALTIMORE—The H. B. Hearn Co., 41 South Gay St., plans to build a plant for the manufacture of chemical mixtures, etc., electrically operated, to turn out about 25 bbl. of sweeping mixture daily. H. B. Hearn, pres. and mgr.

Massachusetts

BOSTON—The Amer. Can Co., 120 Bway., plans to build a factory. Estimated cost, $250,000.

BOSTON—K. J. Quinn & Co., Inc., 80 Batterymarch St., will soon award the contract for the construction of a 2-story, 30x 60-ft. addition to shoe polish factory. Cost, between $18,000 and $20,000.

HOLYOKE—The Amer. Writing Paper Co., 9 Main St., will build a 1-story, 25x75-ft. addition to its paper factory. Estimated cost, $25,000. Work will be done by day labor.

HOLYOKE—The Worthington Pump & Machinery Corp., 37 Appleton St., will soon award the contract for remodeling old schoolhouse into pattern plant, on North Bridge and East Dwight Sts. Estimated cost, $30,000.

Michigan

CADILLAC—The Mercy Hospital is having plans prepared for the construction of a 3-story addition to present hospital. A chemical laboratory will be installed in same. Estimated cost, $100,000. E. Brielmaier Sons, University Bldg., Milwaukee, Wis., archts. and engrs.

Minnesota

FRIDLEY—The Walsh Tie Co., 954 McKnight Bldg., Minneapolis, has awarded the contract for the construction of a creosoting plant to include an office building, factory, power house, retort tanks, etc., to C. F. Haglin & Sons, 226 Lumber Exch., Minneapolis.

LONG PRAIRIE—Indian School Dist. 11 will soon award the contract for the construction of a 2-story, 75x160-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $200,000. W. M. Barber, secy., C. Howard Parsons, 600 Builders Exch., Minneapolis, archt.

MANKATO—The Carney Cement Co. is having plans prepared for the construction of a cement plant, to include a mill building, machine shop, blacksmith shop, chemist's building, 16 steel kilns to measure 60 ft. high and 18 ft. in diameter, etc., north of here. Estimated cost, $150,000. R. K. Meade, 11 East Fayette St., Baltimore Md., engr.

Nebraska

CHADRON—The City Council will receive bids until Nov. 15 for the construction of a complete sewage disposal plant, to include a septic tank, sand filter, etc. Estimated cost, $50,000. R. D. Salisbury Co., 1600 Downing St., Denver, Col., engr.

LINCOLN—Alvord & Burdick, engrs., 8 South Dearborn St., Chicago, are preparing plans for the installation of a sewage disposal plant here. Estimated cost, $330,000.

New Jersey

MAURER—The Barber Asphalt Paving Co., 233 Bway, New York City, has awarded the contract for the construction of a 2-story asphalt plant, to Levering & Garrigues, 552 West 23d St., New York City.

TRENTON—The Star Porcelain Co., Muirhead Ave., has awarded the contract for the construction of a 2-story, 40x80-ft. addition to its factory, to C. R. Randall, 43 North Hermitage St. Estimated cost, $6,500.

New York

BROOKLYN — The Grand Corrugated Paper Co., 30 Crosby St., has awarded the contract for altering its factory on 32d St. to the Gabler Constr. Co., 402 Hudson St., New York City. Estimated cost, $50,000. Noted Oct. 13.

NEW YORK—Paul Schuldeberger will alter the 5-story factory for the manufacture of bristles at 52 Cliff St. Estimated cost, $35,000. Work will be done by day labor.

North Carolina

GREENSBORO—The Carolina Steel & Iron Co. plans to build an 80x180-ft. foundry. Estimated cost, $25,000.

WILMINGTON—The Fisheries Products Co. plans to build a fertilizer plant. Estimated cost, $100,000.

Ohio

CLEVELAND—The Malay Rubber Co., 1035 Guardian Bldg., plans to build a 3-story factory on East 172d St. and St. Clair Ave. Estimated cost, $100,000.

CLEVELAND—Parish & Bingham Co., manufacturers of castings, 11600 Madison Ave., has awarded the contract for the construction of a 1-story, 24x45-ft. heating room, to the E. C. Gaspard Constr. Co., Engineers Bldg. Estimated cost, $10,000.

KENT—The Bd. Educ. is having plans prepared for the construction of a 2-story, 160x200-ft. high school. A chemical laboratory will be installed in same. Esti-

mated cost, $275,000. Mills & Millspaugh, 67 East Long St., Columbus, O., archts.

MANSFIELD—The Superior Brass Mfg. Co. is building a 40x60-ft. addition to its foundry. Estimated cost, $11,000. E. K. Bacon, secy. Althouse & Jones, engrs.

YOUNGSTOWN — The Reserve Iron & Steel Co. plans to build two blast furnaces and a 2,000,000 puddling plant. Estimated cost, $1,000,000.

Pennsylvania

PHILADELPHIA—Baeder & Adamson Co., Richmond and Allegheny Sts., will alter and build a 1-story, 50x120 ft. addition to its present factory for the manufacture of glue. Estimated cost, $56,000.

PHILADELPHIA — Clark & Dudnick, archts. and engrs., Drexel Bldg., will soon award the contract for the construction of a 1-story foundry and woodworking shop on 42d and Walnut Sts. Owner's name withheld.

PITTSBURGH—The Pittsburgh Malleable Iron Co., 57th St. and the Allegheny River, plans to build a 202x322-ft. foundry. Estimated cost, $500,000. F. Chase, 645 North Michigan Ave., Chicago, archt.

Texas

DALLAS—The Lincoln Paint & Color Co., Detroit, Mich., has awarded the contract for the construction of the first unit of its paint factory to be 2-story, 140x180-ft., on Kentucky and Ash Lane, to E. R. Sessums & Sons, Detroit, Mich. Estimated cost, $150,000.

WICHITA FALLS—The State Bd. of Control, Austin, has awarded the contract for the construction of a sewage disposal plant at the Northwest Insane Asylum here, to the James Constr. Co., Dallas, at $47,700.

West Virginia

HUNTINGTON — The International Nickel Co., 43 Exch. Pl., New York City, will build a rolling mill plant. Estimated cost, $3,000,000.

Wisconsin

DRUMMOND—The Rust-Owen Lumber Co. is having preliminary plans prepared for the development of the sewer system, to include the construction of a sewage disposal plant, garage and several small buildings. Estimated cost, $100,000. R. E. Gilchrist, secy. and treas. G. Lister Nason, 641 Endicott Bldg., St. Paul, archt.

RACINE—Alvord & Burdick, engrs., 8 South Dearborn St., Chicago, have submitted a report recommending the abandonment of the present water station and the installation of new pumps, filtration plants and a 36-in. intake from Lake Michigan and about $400,000 of additional distribution system. Estimated cost, $2,000,000.

SCHLEISINGERVILLE — The Zwebell Bros. Co. will soon award the contract for the construction of a 1-story, 60x150-ft. factory for the manufacture of vulcan outfits. Estimated cost, $100,000. Judell & Bogner, 415 Milwaukee St., archts.

Quebec

COLERAINE—The Canada Asbestos and Chrome Co., Ltd., is in the market for equipment.

MONTREAL—The Canada Cement Co., Herald Bldg., Craig St., West, plans to build a 10-story building. Estimated cost, $450,000. Ron & MacDonald, Belmont St., archts.

MONTMAGNY—The Malleable Foundries, Ltd., will receive bids about Nov. 15 for the construction of a foundry. Estimated cost, $75,000.

MONTREAL,—Taylor & Arnold Eng. Co., Ltd., 39 Oller St., plans to build a brass foundry and install equipment in same.

Alberta

EDMONTON—The San Francisco & McMillan Oil Co., Ltd., plans to build a plant. Estimated cost, $500,000.

New Publications

NEW BUREAU OF STANDARDS PUBLICATIONS: Scientific Paper 386, Atomic Theory and Low-Voltage Arcs in Caesium Vapor, by Paul D. Foote and W. F. Meggers; Scientific Paper 387, Permeability of Rubber to Gases, by Junius David Edwards and S. F. Pickering; Scientific Paper 392, A Photographic Method of Detecting Changes in a Complicated Group of Objects, by M. H. Stillman; Tech. Paper 164, Saybolt Viscosity of Blends, by Winslow H.

Herschel; Tech. Paper 165, Enamels for Sheet Iron and Steel, by J. B. Shaw.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 182, Casing Troubles and Fishing Methods in Oil Wells, by Thomas Curtin; Tech. Paper 230, Determination of Molybdenum, by J. P. Bonardi and Edward P. Barrett; Tech. Paper 233, The Properties of Some Stoneware Clays, by H. G. Schurecht; Tech. Paper 238, Indicators for Carbon Dioxide and Oxygen in Air and Flue Gas, by L. H. Milligan, D. O. Crites and W. S. Wilson; Tech. Paper 244, Use of Stenches as a Warning in Mines, by S. H. Katz, V. C. Allison and W. L. Egy; Tech. Paper 266, Coke-Oven Accidents in the United States During the Calendar Year 1919, by William W. Adams.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: Mineral Resources of the U. S. in 1919 (Preliminary Summary), introduction by G. F. Loughlin, statistics assembled by Martha B. Clark, published Sept. 8, 1920; I: C, Mineral Production of the U. S. in 1917, introduction by H. D. McCaskey, summary by Martha B. Clark (Mineral Resources of the U. S., 1917, Part I), published June 28, 1920; 1:24 Gold and Silver in 1918 (General Report), by J. P. Dunlop (Mineral Resources of the U. S., 1918, Part I), published July 15, 1920; 1:28, Lead in 1917, by C. E. Siebenthal (Mineral Resources of the U. S., 1917, Part I), published May 8, 1920.

NEW UNITED STATES TARIFF COMMISSION PUBLICATIONS: Tariff Inf. Series No. 18, Barytes, Barium Chemical, and Lithopone Industries, Including Costs of Production, 1919.

EMISSIVITY OF HEAT FROM VARIOUS SURFACES, by V. S. Day, Bull. 118, published by the University of Illinois, Urbana, Ill. Price 20c.

THE MINERAL INDUSTRY OF THE BRITISH EMPIRE AND FOREIGN COUNTRIES, NITRATES, published by the Imperial Mineral Resources Bureau, London. Price 9d.

DATA BOOK FOR ENGINEERS, published by the Locomotive Superheater Co., New York. This book has been compiled for the purpose of assisting stationary engineers in their everyday work by furnishing them with useful data. Copies will be sent to anyone actually interested in steam engineering.

Manufacturers' Catalogs

THE GAS PRODUCER & ENGINEERING CORP. OF NEW JERSEY, New York City, has issued Bull. 96, on Galusha Suction Type "L" Stationary Gas Producer. Descriptive matter and illustrations are given.

THE TECHNICAL PRODUCTS CO., INC., New York, dealer in new and used equipment, the latter comprising large purchases from Government munitions plants, has recently issued an attractive folder entitled the A B C's of Refrigeration, describing, under the caption of "The Technical Way," the high-speed vertical single acting ring plate valve compressors, which it is handling. Copies can be obtained by addressing the company at its main office, 501 Fifth Ave., New York City.

THE MAGNESIA ASSOCIATION OF AMERICA, Philadelphia, Pa., has published a new book on heat insulation entitled "Defend Your Steam," by Austen Bolam. The book presents the result of four years of original research by the association and the Mellon Institute and covers every phase of heat-and fuel-saving with 85 per cent magnesia pipe and boiler covering. It is well illustrated and contains a variety of data and information on heat and heat losses.

DRIVER-HARRIS CO., Harrison, N. J., has published an excellent booklet entitled "Case Carbonizing." Chapters are devoted to cyanide hardening, gas hardening, lead tempering and hardening, nichrome containers, etc. The booklet is written in language that will be readily understood by the heat treater and will give him the results of the latest scientific investigations in this branch of metallurgy.

THE WEBSTER MFG. CO., 4500 Cortland St., Chicago, has issued the October, 1920, number of "Webster Method," containing articles on recent interesting installations in the materials-handling field. "Webster Method" has been issued since 1911. Its numbers contain descriptions and photographs of recent installations in the coal, grain, mining, chemical and other fields, in which conveying apparatus form so large a factor in conserving hand labor. The subjects of its articles cover not only installations which solve labor handling problems in the United States but often include installations which have been made in for-

eign countries. "Webster Method" is published regularly and distributed free to those who are interested in labor conserving methods.

THE ATERITE CO., INC., New York City calls attention to Bull. 7, on "Aterite Rods and Sheets, Cold Rolled—Cold Drawn." Many interesting illustrations are given, with descriptions and tables of weight of rolled Aterite rods, sheets and plates, and a table showing comparison of different gages, together with equivalent in decimal parts of an inch.

WORTHINGTON PUMP & MACHINERY CO., New York, announces Catalog BK-3,000, illustrating and describing Worthington Marine Pumps and Auxiliaries. The catalog consists of one hundred and twenty-five pages of descriptive matter and illustrations, and should be a comprehensive and useful publication to marine circles generally.

CRESCENT SALES & ENGINEERING CO., Detroit, Mich., calls attention to a new catalog on Crescent "Roto-Piston" Vacuum and Pressure Pumps. The booklet contains descriptions of Roto-Piston vacuum pump and blower, pump description and performance, view of assembling department, uses of pumps, description of operation phantom of pumps and parts, vacuum chucks, special pumps, vacuum time curves, pressure curves, vacuum pump data, details of foundation, etc., list of parts and instructions for installing and operating.

THE ACHESON GRAPHITE CO., Niagara Falls, N. Y., announces a new publication entitled "Electric Furnaces." Section I deals with electric furnaces made in the United States and Canada and Section II with electric furnaces made in the United Kingdom and Continental Europe. Illustrations are given of many of the furnaces.

BUFFALO FOUNDRY & MACHINE CO., Buffalo, N. Y., recently issued an attractive booklet on "Some Recent Developments in Buflovak and Buflokast Apparatus." The booklet covers some recent developments in vacuum driers, evaporators, vacuum pans, chemical equipment, sugar apparatus, etc.

BLAW-KNOX CO., Pittsburgh, Pa., has issued two new folders entitled "Blaw Bulldog Buckets" and "A Discussion of Lever Arms."

ELECTRO BLEACHING GAS CO., New York City, has published a new textile bleaching booklet entitled "Liquid Chlorine." This attractive catalog contains various formulas used for the making up of a bleaching solution from liquid chlorine.

CUTLER-HAMMER MFG. CO., Milwaukee, Wis., calls attention to Pub. 860, which takes up in a general way the control of motor-driven pumps and compressors on water and compressed air systems, in mines, on board ships, for hydraulic elevators, etc. Every C-H product used for this class of service is described, including manual and automatic starters and speed regulators, and accessories, such as pressure regulators, float switches, push buttons, etc. A condensed chart is given to aid in the selection of the proper control equipment for each particular class of service.

THE DINGS MAGNETIC SEPARATOR CO., of Milwaukee, Wis., has issued Bull. 81, describing several types of magnetic separators. Among these is included the new Type C magnetic separator, which is designed for separating fine granular material. It is of the medium intensity and cross-belt type, and is used for extracting iron from brass and aluminum borings and turnings, iron from glass sand, abrasive material, rubber buffings, fireclay, cattle and poultry food, phonograph record material, etc. The material to be separated passes through two positive magnetic zones.

THE SPECIAL CHEMICAL CO., of Highland, Ill., has issued a new bulletin on Pfanstiehl sugars, which are used in bacteriology for differentiating various disease-producing micro-organisms.

THE ARTHUR R. MAAS LABORATORIES, Los Angeles, Cal., has issued an attractive catalog on "Chemistry and You," which is published for the purpose of acquainting the reader of its business—chemical service. This booklet contains interesting write-ups on: The Misunderstood Chemist; Yesterday and Tomorrow; Lazy Materials; Sherlock and the Chemist; Counting the Bugs; Buying on Faith; Chemical Specifications; Our National Beverage; Gasoline vs. Coal Oil; The Chemical Alphabet; Exit Snails; Wasted Advertising; Insurance Adjustments; Chemical Gold Bricks; The Wrong Foot First; From Test Tube to Factory; Unhatched Dollars; Profits in Waste; Before Judge and Jury; Chemical Advertising and a Word About Ourselves.

THE DENVER FIRE CLAY CO., Denver, Col., has just received from the press a 32-page

illustrated bulletin on Oil Shale Equipment. At first is a brief review of the shale-oil industries in Scotland, and a description showing occurrence of oil shale in the United States. Following this are a number of illustrated methods for the preliminary or field distillation of oil shale, and also lists and descriptions of apparatus used in the oil shale industries, followed by a number of oil shale retorts and plants.

THE AJAX METAL CO., Philadelphia, Pa., calls attention to its new export catalog which has been published in two editions, one English and one Spanish. The text and illustrations are in both cases identical. This book covers all Ajax products from Babbitt metals to car brasses and castings, and ingot metal, and is a comprehensive book on the metal field for export use. The book is illustrated.

MANIERRE ENGINEERING & MACHINERY CO., Milwaukee, Wis., has just issued its 1920 catalog, which contains illustrations of the latest installation of the company's seven different types of loaders, showing the wide application of these machines in the United States and Canada.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its 1920 meeting Dec. 27, 1920, to Jan. 1, 1921, at Chicago, Ill.

AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting on employment and education in the Congress Hotel, Chicago, on Nov. 12.

AMERICAN CERAMIC SOCIETY will hold its annual meeting the week of Feb. 21, 1921, at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29, 1921.

AMERICAN GAS ASSOCIATION will hold its second annual convention at the Hotel Pennsylvania, New York, Nov. 15 to 20.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its winter meeting at New Orleans, Dec. 6 to 9. Headquarters will be at the Hotel St. Charles.

AMERICAN MINING CONGRESS will hold its next convention in Denver Nov. 15 to 19.

AMERICAN PETROLEUM INSTITUTE will hold its annual meeting on Nov. 17, 18 and 19, in Washington, D. C. Headquarters will be at the New Willard Hotel.

AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS' 1920 annual meeting will be held in the Engineering Societies' Building from Dec. 7 to 10 inclusive.

FEDERATED AMERICAN ENGINEERING SOCIETIES will hold its first meeting in Washington, D. C., Nov. 18 and 19. American Engineering Council will hold its organization meeting Nov. 20. Headquarters for both will be at the New Willard Hotel.

PHILADELPHIA SECTION, AMERICAN CHEMICAL SOCIETY will hold its regular meeting Nov. 18 at the Engineers' Club, Philadelphia. Ellwood Hendrick will speak on "Relativity and Life."

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: Nov. 19, American Chemical Society; Dec. 10, American Chemical Society, joint meeting with Society of Chemical Industry, American Electrochemical Society and Société de Chimie Industrielle; Jan. 7, American Chemical Society; Jan. 14, Society of Chemical Industry, Perkin Medal award; Feb. 11, American Electrochemical Society, joint meeting with Society of Chemical Industry, American Chemical Society and Société de Chimie Industrielle; March 11, American Chemical Society, Nichols Medal award; March 25, Society of Chemical Industry; April 22, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry, and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.